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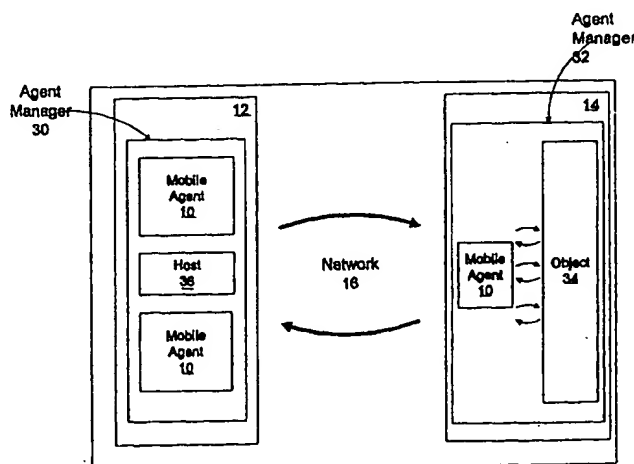
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>G06F 13/00</b>	<b>A1</b>	(11) International Publication Number: <b>WO 98/21662</b> (43) International Publication Date: 22 May 1998 (22.05.98)
(21) International Application Number: PCT/US97/20232 (22) International Filing Date: 12 November 1997 (12.11.97)  (30) Priority Data: 60/030,906 14 November 1996 (14.11.96) US  (71) Applicant: MITSUBISHI ELECTRIC INFORMATION TECHNOLOGY CENTER AMERICA, INC. [US/US]; 201 Broadway, Cambridge, MA 02139 (US).  (72) Inventor: WALSH, Thomas, C.; 47 Tileston Street #2, Boston, MA 02113 (US).  (74) Agent: TENDLER, Robert, K.; 65 Atlantic Avenue, Boston, MA 02110 (US).		(81) Designated States: AU, CA, CN, IL, JP, KR, MX, NO, NZ, SG, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: ITINERARY BASED AGENT MOBILITY INCLUDING MOBILITY OF EXECUTABLE CODE



(57) Abstract

In accordance with the present invention, a mobile agent object (10) executes a first method (18) on a first computer (12), migrates from the first computer (12) to a second computer (14), and executes a second method (20) on the second computer (14). The first and second methods and first and second computers are designated in an itinerary (28). The agent includes both data (22) and executable code (24, 26) which are serialized for transmission from the first computer to the second computer as data. The data containing the agent is then deserialized in the second computer to regenerate the agent in the form of an object. The executable code portion of the agent can be supplemented with code from a home codebase located on another computer.

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TITLE OF THE INVENTION  
ITINERARY BASED AGENT MOBILITY INCLUDING MOBILITY OF  
EXECUTABLE CODE

5

CROSS REFERENCE TO RELATED APPLICATIONS

A claim of priority is made to U.S. provisional patent application Serial Number 60/030,906, entitled USE AND COLLABORATION OF MOBILE AGENTS IN A COMPUTER NETWORK, filed November 14, 1996.

10

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR  
DEVELOPMENT  
Not applicable

15

BACKGROUND OF THE INVENTION

The present invention is generally related to network computing, and more particularly to mobile objects.

20

Mobile objects that are transmitted across a computer network are known. Mobile objects are comprised of code and data, both of which are transmitted across the computer network. Technologies such as client-server protocols, remote procedure call protocols, and distributed object technologies are employed to transmit mobile objects across the computer network. These technologies implement either a "push" model or a "pull" model, both of which have drawbacks.

25

30

In a "pull" model the code for an executing object is downloaded from a network source such as a web server. When a particular portion of code becomes necessary for operation, that portion of code is first sought on the local filesystem. If the local filesystem does not include that portion of the code, a network request is sent to another computer in the network in order to prompt transmission of that portion of code to the local computer. However, as different classes of sub-objects are created, a separate network request must

35

-2-

be sent to retrieve code for each class. In the case of a Hyper-Text Transfer Protocol ("HTTP") request, each request must re-establish a Transmission Control Protocol/Internet Protocol ("TCP/IP") socket connection to the web server. Thus, when downloading a large number of classes, a large number of connections must be established and a large amount of network overhead is incurred.

Another drawback associated with the pull model is that as an object travels, the code which enables the object to operate must be re-downloaded at each computer. More particularly, when the object arrives at each a destination computer, the object downloads any code which is required but not present on the local filesystem, even if that code was downloaded at the previous destination computer. Previously downloaded code is not cached. Network overhead is incurred as a consequence.

In a "push" model the code for an executing object is carried with the mobile object. Prior to launching the mobile object, all of the code that will be needed by the object is identified. The code is packaged with the agent and pushed around the network to each destination computer. While the push model reduces network requests in comparison with the pull model, network overhead is still incurred because of the relatively large amount of code that is pushed to every destination computer. In some cases the object will push code for classes that are no longer needed. For example, an agent may create an instance of a particular class of object only in very exceptional circumstances. In such a case it is inefficient for the object to push the code for this class.

Another limitation of known mobile objects is difficulty in examining and predicting destination information. Known mobile objects initiate travel by performing a subroutine call. The method is sometimes given a name such as "go" or "moveTo," and the caller is responsible for specifying a name or Uniform Resource Locator ("URL") indicating the destination computer for the mobile object. When the travel method is called, the execution of the mobile object is

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halted and the mobile object is converted into a network transmittable form. On the destination computer the mobile object is restored from the network form and restarted. This restart can either occur on the instruction directly following the call to the travel method, or at the beginning of some known method.

## BRIEF SUMMARY OF THE INVENTION

In order to provide efficient mobility of code for a mobile agent object ("agent"), a "mobile codebase" object is constructed. The mobile codebase travels with the agent and serves as a repository of code for classes that facilitate agent operation. When the agent is launched, the launcher specifies a list of related classes. These classes are retained in the mobile codebase. The launcher also specifies a Uniform Resource Locator ("URL") that points to a network source ("home codebase") from which code can be downloaded. If the agent is required to instantiate an object comprising code that is not in the mobile codebase, a network request is sent to the home codebase to retrieve that code. Code that is downloaded in this manner is retained in the mobile codebase.

The combination of the mobile codebase and home codebase improve agent operation and reduce network overhead. In a preferred embodiment an agent is launched with a mobile codebase that is preloaded with classes which are certain to be needed. Classes that are unlikely to be needed are stored in the home codebase. Thus the agent with mobile codebase and home codebase provide the desirable features of the push and pull models without the undesirable network overhead incurred by transmitting unneeded classes around the network or re-downloading code.

Agent travels are defined by an itinerary data structure. The itinerary is composed of a list of destinations, each of which includes: (1) the hostname of a destination computer on the network to which the agent should travel, and (2) the name of a method that the agent should

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execute when the agent arrives at the destination computer. An agent is allowed to modify its itinerary. When an agent modifies its itinerary, the agent owner is automatically notified, thus allowing the owner to "follow" the agent wherever it may travel.

The itinerary provides advantages related to agent and network management. Inspection of the agent itinerary reveals where the agent has travelled and where the agent may travel in the future. Since the itinerary is a standard data structure, an observer can depend on it to be present. Further, since the itinerary is a separate data structure from the agent, the observer does not need special knowledge of the internal structure of the agent in order to examine the itinerary.

#### BRIEF DESCRIPTION OF THE DRAWING

The invention will be more fully understood from the following Detailed Description of the Invention, in conjunction with the Drawing, of which:

Fig. 1 is a block diagram which illustrates agent migration;

Fig. 2 is a block diagram which illustrates agent execution in conjunction with agent migration;

Fig. 3 is a block diagram of an agent;

Fig. 4 is a block diagram of agent interaction with agent managers on multiple computers in a network;

Fig. 5 is a flow chart which illustrates agent mobility;

Fig. 6 is a block diagram which illustrates agent operation according to an itinerary;

Fig. 7 is a block diagram which illustrates the agent runtime environment; and

Fig. 8 is a flow chart which illustrates agent deserialization.

#### DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig. 1, an agent 10 comprises a mobile

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object which can travel from a first computer 12 to a second computer 14 in a computer network 16. The agent is generated and stored in memory on the first computer for a specific purpose, and includes both data and executable code. The agent executes on the first computer and then migrates to the second computer by being transmitted across the network. The agent then resumes execution on the second computer. When the agent completes execution on the second computer, the agent acts in accordance with an agent itinerary. For example, the agent will migrate to another computer if the itinerary so indicates.

Referring now to Figs. 1 and 2, the agent executes a sequence of instructions during operation. In particular, a first method 18 is executed on the first computer 12 and a second method 20 is executed on the second computer 14. As a result, migration between computers is transparent from the perspective of the agent.

Referring to Fig. 4, agent mobility is preferably facilitated through use of JAVA agent manager Objects 32 and an Object Serialization facility (a product of Sun Microsystems which is known in the art). Object Serialization operates to serialize objects such that a representative stream of bytes, i.e., data, is generated therefrom. Object Serialization facilitates transmission of an agent across the network by serializing the agent 10 into a format that is suitable for network transmission. Serialization of the agent may also include serialization of sub-objects which are contained within member variables of the agent. In accordance with the present invention, the serialization process involves the serialization of executable code, data, and an itinerary as hereinafter discussed in greater detail. Once the agent has been serialized, a communication socket to the second computer is opened and the resulting stream of bytes is transmitted to the second computer along the socket.

The serialized agent is regenerated in the second computer 14 upon arrival. In particular, the stream of bytes transmitted along the socket is deserialized in the second

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computer. Deserialization regenerates the agent in the form in which the agent existed prior to migration, i.e., an object. Following deserialization, the agent executes a predetermined method specified by its itinerary. The predetermined method may prompt interaction with another object 34 located on the second computer. When the method has been executed, the agent is serialized and transmitted to yet another computer, or possibly back to the first computer. The agent is therein deserialized upon arrival and proceeds to execute another predetermined method and interact with that computer. In the case of the agent migrating back to the first computer, such interaction could be with a host application 36 through which an information query was entered. The agent continues migrating across the network in this manner as execution requires. Eventually, the agent is terminated when execution of the itinerary is complete. It should be noted that the agent need not necessarily migrate to the initial host (first) computer after executing on a remote (second) computer. The agent could travel to multiple computers, and may not return to the initial host computer.

Referring to Fig. 3, each agent may include data 22, code 24, sub-objects 26 and an itinerary 28. The data portion 22 includes internal state information associated with the agent. The code portion 24 includes executable code associated with operation of the agent. The itinerary portion 28 specifies destinations for the agent. Sub-objects 26 include code of distinct objects contained within the agent. The agent carries the code for these sub-objects.

The code 24 portion of the agent 10 includes a mobile codebase and a reference pointer to a home codebase. The mobile codebase comprises executable code which is retained as part of the agent. When the agent migrates, the mobile codebase is transmitted along with the data, sub-objects and itinerary to the destination. The home codebase is executable code which resides on the computer which originally created and launched the agent or a suitable network server (such as a web server). The reference pointer

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to the home codebase is a Uniform Resource Locator ("URL") that allows remote access to the home codebase from other computers in the network. If the agent requires code that is not present in the mobile codebase during execution, the agent retrieves the required code from the home codebase and retains such retrieved code in the mobile codebase.

Referring to Figs. 3 and 6, the itinerary 28 is a data structure which defines agent migration parameters. The itinerary is composed of a list of destinations and the name of a method associated with each such destination. In a preferred embodiment, each destination entry contains the Transmission Control Protocol/Internet Protocol ("TCP/IP") host name of a computer on the network to which the agent is designated to migrate. The method associated with the respective destination is invoked upon arrival at that destination. Hence, each destination represents a location and a task to be performed at the location.

Figs. 4 and 5 illustrate agent mobility. When the determination is made that the agent should migrate, the agent manager 30 examines the itinerary 28 to ascertain the next destination to which the agent 10 is designated to migrate. The agent manager 30 establishes a network connection to the agent manager 32 at the destination computer 14. The agent manager 30 passes the agent and related travel information to the destination agent manager 32. The agent manager 30 then deletes the local copy of the agent, terminates any execution threads which were being used by the agent, and performs other appropriate clean up activities.

From the perspective of the destination computer, the agent arrives at the destination computer as illustrated in step 38. As previously described, the agent arrives in the form of data which includes the code, sub-objects, itinerary and other data. Java/Object Serialization assists the deserialization and reconstruction of the agent as depicted in step 40. The server then spawns a new thread in which the agent will execute as shown in step 42. A persistent local copy of the agent is then made as illustrated in step 44.

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As depicted in step 46 the agent manager invokes the proper method of the agent for execution in the spawned thread at this node. The itinerary contains information indicating which method should be invoked at each designated destination computer. The agent then executes as illustrated in step 50.

5 When the agent has completed execution of the indicated method, another persistent copy of the agent is stored on the local disk as depicted in step 52 in order to prevent redundant execution in the event that the computer malfunctions before the agent migrates. The agent manager then examines the agent itinerary as illustrated in decision step 54. If the itinerary does not indicate any further destinations then agent execution is deemed complete as shown in step 56. However, if the itinerary indicates further destinations, then the agent manager determines whether the next destination is associated with another computer in decision step 58. If the next destination is not another computer, flow returns to step 44, thereby bypassing network traffic. However, if the next destination is associated with a different agent manager then a network connection to the indicated agent manager is established as depicted in step 60. The destination contains a string which indicates where to travel. The string contains either the name (host name) of a computer or a URL to a distributed object. The agent is then serialized as illustrated in Step 62 and subsequently transmitted to the next agent manager as depicted in Step 64.

10 Migration in accordance with the itinerary 28 is further illustrated in Fig. 6. The itinerary includes a listing including identification of each agent manager 66 to which the agent is configured to migrate and identification of a method 68 to execute at each respective agent manager. The agent migrates through the agent managers listed in the itinerary sequentially in the order in which the servers are listed, invoking each respective method upon arrival. Such method could be, for example, querying or updating a database on the destination computer.

15 Fig. 7 illustrates the agent runtime environment. Each



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computer 70 on the network includes a Java Virtual Machine 72 running therein. A agent manager 74 runs on each respective Virtual Machine 72. The agent manager includes a plurality of threads 76, each thread having an agent 78 associated therewith. In particular, a new thread is formed when a new agent arrives at the server, and the agent executes on that thread. Security mechanisms prevent each agent from operating outside the scope of the associated thread. When agent execution completes, the agent migrates to the next destination identified in the itinerary.

In order for migration and execution to function properly, the agent manager modifies the mechanism by which Java loads classes. The Java standard library provides an object called a "ClassLoader" which can be subclassed by a programmer to modify the rules that Java follows to load classes. The ClassLoader class allows web browsers to download "applets" from a web server. The agent manager provides a specialized ClassLoader which allows the executable code for mobile agents to travel with the agent.

During a typical execution of a Java program, a Java interpreter loads classes as needed for execution from a logical file system on the local computer. However, agents become separated from the home computer and the home codebase during migration, i.e., agents are separated from the directory or directories on the filesystem of the home computer where the code is stored. Further, sub-objects sometimes need to be created as the agent executes, either as member variables or as temporary variables within the methods. These sub-objects could be instances of classes which are part of the standard Java packages or they could be instances of new classes written by the programmer of the agent. However, since the agent is executing on a different computer than the home computer following migration, the Java virtual machine may not be able to directly retrieve the code for the particular sub-object. To allow agents to properly load classes and construct objects when remote from the home computer, a special ClassLoader is employed by the agent manager whenever an agent attempts to construct an object.

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The ClassLoader object first attempts to locate a class on the local file system of the computer. If the class is not on the local file system, the ClassLoader searches the mobile codebase. If such attempt fails, the ClassLoader sends a request back to the home machine of the agent. The agent's travel information contains a reference such as a URL which refers back to the home codebase on the home computer, and by accessing the URL the ClassLoader can retrieve classes from the home computer.

Agent deserialization is illustrated in Fig. 8. As depicted in step 80 the serialized agent arrives as a stream of data. Java Development Kit Object Serialization classes then call an agent manager related method to perform deserialization as shown in step 82. The method reads agent related objects from the object stream as depicted in step 84. In particular, the mobile codebase, itinerary and codebase URL are read by the method. A custom Classloader and ObjectInputStream are constructed as shown in step 86. Object Serialization then reads the agent and other objects from the input stream as depicted in step 88 and step 90, respectively. When the related objects are read, the ClassLoader retrieves the classes which comprise the agent as illustrated in step 92.

The new object's class is loaded once the classes are retrieved. As depicted in step 94, if the class is determined to have been previously loaded then the previously loaded class instance is employed (step 96) and the object is instantiated using the loaded class object as shown in step 98. However, if the class has not been previously loaded as determined in inquiry step 94, then inquiry is made as to whether the class is on the local class path of the destination computer as illustrated in decision step 100. If the class is present on the local machine then the class is loaded therefrom as shown in step 102 and the object is instantiated using the loaded class object as depicted in step 98. However, if the class is not found on a local class path as shown in step 100 then an inquiry is made as to whether the class is in the mobile codebase as shown in step

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104. If the class is located in the mobile codebase then the class is loaded therefrom as shown in step 106 and the object is instantiated using the loaded class object as shown in step 98. However, if the class is not located in the mobile codebase in decision step 104 then the class is loaded by  
5 accessing the home codebase as shown in step 108. If the codebase pointer is an Internet type pointer such as a Hyper-Text Transfer Protocol ("HTTP") URL, as determined in inquiry step 110, then an HTTP request is sent to the local web  
10 server as shown in step 112 and the retrieved class is added to the Mobile CodeBase as depicted in step 114. However, if the codebase URL is not a HTTP URL then a remote method request is sent to a RemoteClassLoader object as shown in  
15 step 116 and the class is added to the mobile codebase as shown in step 114. In either case, the object is instantiated using the loaded class object as shown in step 98. If more objects exist in the stream to be retrieved, as determined in decision step 118, then another object is read from the input stream as illustrated in step 90. If there  
20 are no more objects to be retrieved, flow terminates.

Having described the preferred embodiments of the invention, other embodiments which incorporate concepts of the invention will now become apparent to one of skill in the art. Therefore, the invention should not be viewed as  
25 limited to the disclosed embodiments but rather should be viewed as limited only by the spirit and scope of the appended claims.

A program listing follows in the attached APPENDIX.

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- 12 -

```

Agent.java_1      Tue Nov 12 08:01:22 1996      1
1  /* $Header: /com/meitca/hsl/zonesagents/shared/Agent.java 13  9/30/96 6:23p Walsh $
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Base class for mobile Agent
11  *
12  * $Log: /com/meitca/hsl/zonesagents/shared/Agent.java $
13  *
14  * 13  9/30/96 6:23p Walsh
15  * clean up javadoc comments
16  *
17  * 12  9/29/96 4:09p Walsh
18  * Give Agent access to AgentPackage information
19  *
20  * 11  9/28/96 6:57p Walsh
21  * Comment out debug printin
22  *
23  * 10  9/09/96 4:53p Walsh
24  * Add prepareForTransport, completedTransport methods
25  *
26  * 9  9/04/96 3:18p Noemi
27  * Added static initializer. Moved functionality related to collaboration
28  * to new CollaboratorAgent subclass.
29  *
30  * 8  8/30/96 4:30p Noemi
31  * Changed constructors and finalizer to operate on AgentGroup references
32  * (rather than AgentGroupImpl references).
33  *
34  * 7  8/28/96 2:45p Noemi
35  * Removed SourceSafe conflict garbage.
36  *
37  * 6  8/28/96 2:20p Noemi
38  * Added support for AgentGroups.
39  *
40  * 5  8/23/96 3:52p Walsh
41  * Remove live method (superceded by ad-hoc invocation)
42  *
43  * 4  8/22/96 6:36p Walsh
44  * Remove parameter to live method
45  *
46  * 3  8/13/96 2:23p Walsh
47  * Add some comments & documentation

```

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Agent.java\_1 Tue Nov 12 08:01:22 1996 2

```

48 *
49 * 2      8/09/96 4:49p Walsh
50 */
51 package com.meitca.hsl.zonesjagents.shared;
52
53 import java.util.*;
54 import java.net.InetAddress;
55
56 import com.meitca.hsl.zonesjagents.conduit.*;
57
58
59 /**
60 * A base class representing a traveling agent program. All user defined
61 * agents should be derived from the class Agent. An agent
62 * travels from machine to machine as dictated by its Itinerary. At each stop,
63 * a specified method will be invoked. After the method completes, the Agent
64 * will be sent to the next host on the itinerary. To develop an agent, a
65 * programmer should derive a class from Agent.
66 * @see ConduitServer
67 * @see AgentGroup
68 * @author Noemi Paciorek
69 * @author Thomas Walsh
70 */
71 public abstract class Agent {
72
73     // Class variables
74     /** A counter used to generate the Agent's ID */
75     protected static int agentNum = 0; // counter for agents started on a system
76
77     /** A unique ID representing the host the agent was initiated from */
78     protected static String host; // unique host ID
79
80     // Instance variables
81     /** A unique ID representing the Agent */
82     protected String agentID; // unique agent ID
83
84     // A reference to the Agent's AgentPackage. This reference will only be
85     // valid when the Agent is actually travelling. Prior to travel, this
86     // will be a null reference (for example the reference will be null
87     // when the Agents constructor is executing).
88     private AgentPackage itsPackage;
89
90     // Static initializer
91     static {
92         /*
93          * Try to obtain the host's name and IP address. If this fails,
94          * construct a pseudo-random name and hope for the best! (Of course,

```

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Agent.java\_1 Tue Nov 12 08:01:22 1996 3

```

95  * this should never happen.)
96  */
97  try {
98      host = InetAddress.getLocalHost().toString();
99      } catch (Exception e) {
100          host = "___FOSTID___" + new Random().nextLong();
101      }
102  }
103
104  // Constructors
105  /** Constructs an Agent */
106  public Agent() {
107      * Assign a unique agent ID.
108      */
109      try {
110          agentID = host + "/agent" + nextAgentNum();
111          //System.out.println("Agent ID = " + agentID);
112      } catch (Exception e) {
113          System.out.println("Agent constructor error: " + e.getMessage());
114          e.printStackTrace();
115      }
116  }
117
118      itsPackage = null;
119
120  }
121
122  // Class methods
123  private final synchronized int nextAgentNum() {
124      return ++agentNum;
125  }
126
127  // Instance methods
128  /**
129   * Retrieves the Agents's ID. An AgentID is a unique String
130   * which identifies a particular instance of an Agent.
131   * @return The Agent's ID.
132   */
133  public final String getAgentID() {
134      return agentID;
135  }
136
137  /**
138   * Converts an Agent to a String. Implementation simply
139   * returns the AgentID.
140   * @return A String representation of the Agent.
141   */

```

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```

Agent.java_1      Tue Nov 12 08:01:22 1996      4

142 public final String toString() {
143     return getAgentID();
144 }
145
146 /**
147  * This is called by the ConduitServer immediately prior to
148  * the agent being transported to its next destination. Derived
149  * Agents can override this method to perform any final processing
150  * needed before transport
151  */
152 public void prepareForTransport() {
153 }
154
155 /**
156  * This is called by the ConduitServer when the Agent arrives at
157  * its new destination. Derived Agents can override this method
158  * to perform any processing needed on arrival
159  */
160 public void completedTransport() {
161 }
162
163 /**
164  * Returns a reference to the Agents Itinerary. The Itinerary
165  * is only available when the Agent is traveling. It is not
166  * available during the Agent's constructor. If the Itinerary
167  * is not available, this method returns null.
168  * @return The Agents Itinerary or null if the itinerary is
169  *         not available
170  */
171 public Itinerary getItinerary() {
172     if (itsPackage != null) {
173         return itsPackage.getItinerary();
174     } else {
175         return null;
176     }
177 }
178
179 /**
180  * Returns a URL pointing to the Agent's codebase on its home machine.
181  * This URL is used in conjunction with the AgentCodebase class to
182  * retrieve the bytecodes of the Agent and its related classes.
183  * The URL available when the Agent is traveling. It is not
184  * available during the Agent's constructor. If the URL
185  * is not available, this method returns null.
186  * @return The URL of the Agents codebase or null if the URL is
187  *         not available
188  */

```



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```
Agent.java_1      Tue Nov 12 08:01:22 1996      5

189      public String getHomeCodebaseURL() {
190          if (itsPackage != null) {
191              return itsPackage.getHomeCodebaseURL();
192          } else {
193              return null;
194          }
195      }
196
197      /**
198       * This Method is called internally by the ConduitServer to
199       * provide the Agents with a reference to its package.
200       */
201      public void setPackage(AgentPackage agentPackage) {
202          itsPackage = agentPackage;
203      }
204
205  }
```

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```

AgentCodebase.java_1      Tue Nov 12 08:01:22 1996      1      11/11/96 5:25p Billp $
1  /* $Header: /com/meitca/hsl/zonesjagents/shared/AgentCodebase.java 3
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Class providing accessibility to the home codebase of the agent
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/shared/AgentCodebase.java $
13 *
14 * 3 11/11/96 5:25p Billp
15 * Made correction to company name
16 *
17 * 2 9/30/96 6:23p Walsh
18 * clean up javadoc comments
19 *
20 * 1 9/28/96 6:35p Walsh
21 * initial version:
22 *
23 */
24 package com.meitca.hsl.zonesjagents.shared;
25
26 import java.net.*;
27 import java.io.*;
28 import sun.net.www.MeteredStream;
29
30 import com.meitca.hsl.zonesjagents.remoteloader.*;
31
32 /**
33 * The AgentCodebase class provides accessibility to the "home
34 * codebase" of an agent. As an agent travels, it may construct
35 * an object whose bytecodes may not be installed on the machine
36 * to which it has travelled. In some cases, the agent may have
37 * already constructed another instance of the same class or, the
38 * user or programmer may have specified that this class was a
39 * "related class" when launching the agent. In both of these
40 * cases, the bytecodes for the class should have already been
41 * loaded into the Agent's MobileCodebase. If the bytecodes for
42 * the new object HAVE NOT already been loaded into the MobileCodebase,
43 * the ConduitServer needs a mechanism for finding an retrieving
44 * these bytecodes. The AgentCodebase provides an mechanism through
45 * which Agents can retrieve code from their home locations.
46 * @see Agent
47 * @see MobileCodebase

```

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```

AgentCodebase.java_1      Tue Nov 12 08:01:22 1996      2
48  * @author      Thomas Walsh
49  */
50  public class AgentCodebase {
51  /**
52   * these constants identify the protocols that
53   * can be used to retrieve bytecodes from an
54   * agents codebase.
55   */
56   static final int UNKNOWN = -1;
57   static final int RMI = 0;
58   static final int HTTP = 1;
59   static final int FILE = 2;
60
61  /**
62   * The protocol to use to retrieve bytecodes from the
63   * AgentCodebase
64   */
65   int
66       itsProtocol;
67
68   /** An URL pointing back to the AgentCodebase */
69   String
70       itsURL;
71
72   /** A ClassFileLoader object which may be used to
73   * retrieve agent bytecode; from the local filesystem
74   * (when a file: url is used to identify the codebase
75   */
76   ClassFileLoader itsClassFileLoader;
77
78   /**
79   * Constructs an AgentCodebase from the given URL.
80   * @param url An URL pointing to the AgentCodebase. This
81   *           URL can be: <br>
82   *           <ul>
83   *           <li>An HTTP url pointing to a location on a web server
84   *           (such as <b>http://host/directory</b>)</li>
85   *           <li>An RMI url pointing to a RemoteClassLoader
86   *           server (such as <b>rmi://host/RemoteClassLoader/directory</b>)</li>
87   *           <li>A FILE url pointing to a local directory
88   *           (such as <b>file:C:\directory</b>)</li>
89   *           <li>An empty string or null which indicates that the agents code
90   *           is on the CLASSPATH of this machine.
91   *           </ul>
92   */
93   * @exception      MalformedURLException If the url passed in was invalid
94   */
95   public AgentCodebase(String url) throws MalformedURLException {
96       itsProtocol = -1;

```

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```

AgentCodebase.java_1      Tue Nov 12 08:01:22 1996      3

95     itsURL = null;
96     itsClassLoader= null;
97     parseURL(url);
98
99     if (itsProtocol == FILE)
100         itsClassLoader = new ClassFileLoader();
101
102     )
103
104     /**
105      * Retrieve the bytecodes for the given class
106      * @param      classname The name of the class whose bytecodes to
107      *              retrieve
108      * @return      The classes bytecodes in the form of a byte array
109      * @exception   ClassNotFoundException If the class could not be loaded
110      */
111     public byte[] retrieveCode(String classname) throws ClassNotFoundException {
112         switch (itsProtocol) {
113             case RMI:
114                 return RemoteClassLoaderImpl.retrieveRemoteClass(itsURL, classname);
115             case HTTP:
116                 return retrieveHTTPClass(classname);
117             case FILE:
118                 return itsClassLoader.loadClassFileFromDirectory(itsURL, classname);
119             default:
120                 throw new ClassNotFoundException("Unsupported protocol");
121         }
122     }
123
124     /* Used internally to parse URL passes into ctor */
125     private void parseURL(String url) throws MalformedURLException {
126         if (url != null) {
127             int sep = url.indexOf(':');
128             if (sep != -1) {
129                 String protocol = url.substring(0, sep);
130                 if (protocol.equals("rmi")) {
131                     itsProtocol = RMI;
132                     itsURL = url;
133                 } else if (protocol.equals("http")) {
134                     itsProtocol = HTTP;
135                     itsURL = url;
136                 } if (itsURL.endsWith("/")) {
137                     itsURL = itsURL.substring(0, itsURL.length()-1);
138                 }
139             } else if (protocol.equals("file")) {
140                 itsProtocol = FILE;
141             }
142         }
143     }

```

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```

AgentCodebase.java_1      Tue Nov 12 08:01:22 1996      4
142      // strip off the file: portion so all we are left with is
143      // the directory spec of the codebase.
144      itsURL = url.substring(sep+1, url.length());
145
146      } else {
147          // we will assume file since the user might be trying to specify a
148          // DOS style filename (ie C:\WINNT)
149          itsProtocol = FILE;
150          itsURL = url;
151      }
152      } else {
153          // assume file
154          itsProtocol = FILE;
155          itsURL = url;
156      }
157      } else {
158          // the URL was null. This means that the Agents code is located somewhere on
159          // the class path of this machine. We will set the protocol to FILE and leave
160          // the url as null
161          itsProtocol = FILE;
162      }
163      }
164
165      /* Used internally to retrieve .class files from a web server */
166      private byte[] retrieveHTTPClass(String classname) throws ClassNotFoundException {
167      try {
168          // first we will try to load the agent using its fully qualified class
169          // name. If the HTTP URL was http://host/Agents and the class name
170          // was Test.Agent, we will build an URL like the following:
171          // http://host/Agents/test/TestAgent.class
172          URL      classUrl = new URL(itsURL + "/" + classname.replace('.', '/') + ".class");
173
174          MeteredStream      stream = (MeteredStream)classUrl.getContent();
175          int      length = stream.available();
176          byte      data[] = new byte[length];
177
178          stream.read(data);
179          return data;
180      } catch (IOException icerror) {
181          // The fully qualified class name didn't work, so lets try to
182          // strip off all of the package names and search for just the
183          // class name. If the HTTP URL was http://host/Agents and the class name
184          // was Test.Agent, we will build an URL like the following:
185          // http://host/Agents/TestAgent.class
186          int lastSep = classname.lastIndexOf('.');
187          if (lastSep != -1) {
188              try {

```

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```

AgentCodebase.java_1      Tue Nov 12 08:01:22 1996      5
                                URL
                                classUrl = new URL(itsURL + "/" + classname.substring(lastSe:

189 + 1, classname.length()); + ".class");
190
191     MeteredStream    stream = (MeteredStream)classUrl.getContent();
192     int              length = stream.available();
193     byte             data[] = new byte[length];
194
195     stream.read(data);
196     return data;
197     : catch (Exception error) {
198         throw new ClassNotFoundException("Could not load class " + classname + "from
199         " + itsURL);
200     } else {
201         throw new ClassNotFoundException("Could not load class " + classname + "from " + its
202         RL);
203     } catch (Exception error) {
204         throw new ClassNotFoundException("Could not load class " + classname + "from " + itsURL);
205     }
206
207 }

```

```

AgentConstants.java_1      Tue Nov 12 08:01:23 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/shared/AgentConstants.java 2 11/11/96 5:25p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Constants used by Java Agents system.
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/shared/AgentConstants.java $
13 *
14 * 2 11/11/96 5:25p Billp
15 * Made correction to company name
16 *
17 * 1 10/10/96 5:50p Walsn
18 * initial version
19 *
20 */
21 package com.meitca.hsl.zonesjagents.shared;
22
23 import java.io.File;
24
25 /**
26 * Class contains constants used within the Java Agent System.
27 */
28 public class AgentConstants {
29     /**
30      * Contains the value of the "zones.home" property (which
31      * points to the Zones installation directory)
32      */
33     public static String ZONES_HOME;
34
35     /**
36      * Contains the value of the "zones.user.home" property (which
37      * points to the Zones user specific directory)
38      */
39     public static String ZONES_USER_HOME;
40
41     /**
42      * Contains the path of the images subdirectory of the Zones
43      * installation directory.
44      */
45     public static String IMAGE_DIR;
46
47     /**

```

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```

AgentConstants.java_1      Tue Nov 12 09:01:23 1996      2

48  * Contains the path of the Agent subdirectory of the Zones
49  * installation directory.
50  */
51  public static String  AGENT_DIR;
52
53  /**
54  * Contains the path of the lib subdirectory of the Zones/Agents
55  * installation directory.
56  */
57  public static String  AGENT_LIB_DIR;
58
59  /**
60  * Contains the path of the Agent subdirectory of the Zones
61  * installation directory.
62  */
63  public static String  USER_AGENT_DIR;
64
65
66  /** Static_INITIALIZER is used to initialize some of the CONSTANTS */
67  static {
68      ZONES_HOME = System.getProperty("zones.home", File.separator + "Zones");
69      if (ZONES_HOME != null) {
70          // terminate the directory name with a separator if
71          // it's not already terminated
72          if (!ZONES_HOME.endsWith(File.separator))
73              ZONES_HOME += File.separator;
74
75          IMAGE_DIR = ZONES_HOME + "images" + File.separator;
76          AGENT_DIR = ZONES_HOME + "Agents" + File.separator;
77          AGENT_LIB_DIR = AGENT_DIR + "lib" + File.separator;
78      }
79
80      ZONES_USER_HOME = System.getProperty("zones.user.home");
81      if (ZONES_USER_HOME == null) {
82          // the zones.user.home Property was not defined.
83          // try the user.home Property
84          ZONES_USER_HOME = System.getProperty("user.home", "");
85          if (ZONES_USER_HOME != null) {
86              // terminate the directory name with a separator if
87              // it's not already terminated
88              if (!ZONES_USER_HOME.endsWith(File.separator))
89                  ZONES_USER_HOME += File.separator;
90
91              ZONES_USER_HOME += ".Zones";
92          }
93      }
94

```



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```
AgentConstants.java_1      Tue Nov 12 08:01:23 1996      3

95  if (ZONES_USER_HOME != null) {
96      // terminate the directory name with a separator if
97      // it's not already terminated
98      if (!ZONES_USER_HOME.endsWith(File.separator))
99          ZONES_USER_HOME += File.separator;
100
101      USER_AGENT_DIR = ZONES_USER_HOME + "Agents" + File.separator;
102  }
103
104  }
```

```

ClassFileLoader.java_1      Tue Nov 12 08:01:23 1996      1      11/11/96 5:25p Billp $

1  /* $Header: /com/meitca/hsl/zonesjagents/shared/ClassFileLoader.java 3
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Loads a *.class" file off of the local filesystem.
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/shared/ClassFileLoader.java $
13 *
14 * 3 11/11/96 5:25p Billp
15 * Made correction to company name
16 *
17 * 2 9/30/96 6:23p Walsh
18 * clean up javadoc comments
19 *
20 * 1 9/28/96 6:35p Walsh
21 * initial version
22 *
23 */
24 package com.meitca.hsl.zonesjagents.shared;
25
26 import sun.tools.java.*;
27 import java.io.*;
28
29 /**
30 * The ClassFileLoader class loads a Classes bytecodes off of the
31 * local filesystem. The user can either specify a particular directory
32 * from which the bytecodes should be retrieved, have the ClassFileLoader
33 * search the system CLASSPATH or specify a custom Class Path which should
34 * be searched for the bytecodes.
35 * @author Thomas Walsh
36 */
37 public class ClassFileLoader {
38     /**
39      * The ClassPath which should be searched for ClassFiles. This could
40      * represent the system CLASSPATH, or a custom ClassPath specified by the
41      * user.
42      */
43     ClassPath itsClassPath;
44
45     /**
46      * Constructs a ClassFileLoader object. This constructor sets the
47      * ClassFileLoader up so that it will search the system's CLASSPATH.

```

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```

ClassFileLoader.java_1      Tue Nov 12 08:01:23 1996      2

48      */
49      public ClassFileLoader() {
50          itsClassPath = new ClassPath(System.getProperty("java.class.path"));
51      }
52
53      /**
54       * Constructs a ClassFileLoader object. The pathstr parameter specifies
55       * a custom ClassPath from which bytecodes are to be retrieved.
56       * @param pathstr A custom ClassPath from which bytecodes are to be
57       *               retrieved
58       */
59      public ClassFileLoader(String pathstr) {
60          itsClassPath = new ClassPath(pathstr);
61      }
62
63      /**
64       * Loads a class from the objects class path. Depending on which
65       * version of the constructor was used, this could mean that the
66       * system's CLASSPATH is searched or that a custom user-defined
67       * ClassPath is searched.
68       * @param      classname The fully qualified class name of the class to
69       *                       be loaded.
70       * @return      The bytecodes for the requested class in the form of a
71       *               byte array
72       * @exception   ClassNotFoundException If the class could not be located on
73       *               the ClassPath
74       */
75      public byte[] loadClassFileFromClassPath(String classname) throws ClassNotFoundException {
76          String filename = classname.replace('.', File.separatorChar) + ".class";
77          ClassFile file = itsClassPath.getFile(filename);
78
79          if (file != null) {
80              try {
81                  long length = file.length();
82                  InputStream stream = file.getInputStream();
83                  byte data[] = new byte[(int)length];
84
85                  stream.read(data);
86                  return data;
87              } catch (IOException e) {
88                  throw new ClassNotFoundException(e.getMessage());
89              }
90          } else {
91              throw new ClassNotFoundException("ClassFile not found on ClassPath: " + classname);
92          }
93      }
94

```

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```

JASProperties.java_1      Tue Nov 12 08:01:23 1996      1      11/11/96 5:25p Billp $
1  /*      $Header: /com/meitca/hsl/zonesjagents/shared/JASProperties.java 4
2  *
3  *      Copyright 1996 Horizon Systems Laboratory,
4  *      Mitsubishi Electric Information Technology Center America.
5  *      All rights reserved.
6  *
7  *      CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  *      DESCRIPTION
10  *      Zones Agent Property File implementation.
11  *      $Log: /com/meitca/hsl/zonesjagents/shared/JASProperties.java $
12  *
13  *      4      11/11/96 5:25p Billp
14  *      *      Made correction to company name
15  *
16  *      3      10/10/96 5:56p Walsh
17  *      *      Make use of constants in AgentConstants class
18  *
19  *      2      10/10/96 2:30p Walsh
20  *      *      Add default constructor
21  *
22  *      1      10/07/96 5:07p Walsh
23  *      *      intial versions
24  *
25  */
26 package com.meitca.hsl.zonesjagents.shared;
27
28 import java.io.*;
29 import java.util.*;
30
31 /**
32  * The JASProperties supports the storage of
33  * user specific and server specific properties.
34  *
35  * <ul>
36  * <li>User specific properties are stored in
37  *     zones.user.home\Agents directory. If the
38  *     zones.user.home System property is not defined,
39  *     user properties are stored in the
40  *     user.home\Zones\Agents directory
41  * <li>Server specific properties are stored in
42  *     zones.home\Agents\Lib
43  *
44  * </ul>
45  *
46  * @see      Properties
47  * @author    Joe DiCelle
48  * @author    Tom Walsh
49  */
50 public class JASProperties extends PropertyFile {

```

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```
ClassLoader.java_1      Tue Nov 12 08:01:23 1996      4

141         return data;
142     } else {
143         throw new ClassNotFoundException("Could not find " + classname +
144         " in directory " + dir);
145     }
146 }
147 } catch (IOException e) {
148     throw new ClassNotFoundException("Could not load " + classname +
149     ". Error: " + e.getMessage());
150 }
151 }
152 }
```

ClassFileLoader.java\_1 Tue Nov 12 08:01:23 1996 3

```

95  /**
96   * Loads a class from a particular directory.
97   * @param dir The directory from which to retrieve the class. If
98   *   this parameter is null or an empty string, the ClassPath
99   *   is searched for the class
100   * @param classname The fully qualified class name of the class to
101   *   be loaded.
102   * @returns The bytecodes for the requested class in the form of a
103   *   byte array
104   * @exception ClassNotFoundException If the class could not be located on
105   *   the ClassPath
106   */
107  public byte[] loadClassFileFromDirectory(String dir, String classname) throws ClassNotFoundException {
108      // if a null or an empty string was passed in for dir, fall back to
109      // searching the class path for the class
110      if ((dir == null) || (dir.length() == 0))
111          return loadClassFileFromClassPath(classname);
112
113      // place a separator char on the end of the directory specification
114      // if it does not already have one
115      if (!dir.endsWith(File.separator)) {
116          dir = dir + File.separator;
117      }
118
119      String fullFilename = dir + classname.replace('.', File.separatorChar) + ".class";
120
121      try {
122          File file = new File(fullFilename);
123
124          if (file.exists()) {
125              long length = file.length();
126              FileInputStream stream = new FileInputStream(file);
127              byte data[] = new byte[(int)length];
128
129              stream.read(data);
130              return data;
131          } else {
132              int lastSep = classname.lastIndexOf('.');
133              if (lastSep != -1) {
134                  String filename = dir + classname.substring(lastSep + 1, classname.length())
135                      + ".class";
136                  file = new File(filename);
137                  long length = file.length();
138                  FileInputStream stream = new FileInputStream(file);
139                  byte data[] = new byte[(int)length];
140                  stream.read(data);

```

JASProperties.java\_1 Tue Nov 12 08:01:23 1996 2

```

48  /**
49   * This constant should be passed into constructor to
50   * specify that this object will contain <b>Server</b>
51   * specific properties.
52   */
53   public static final int SERVER = 0;
54
55  /**
56   * This constant should be passed into constructor to
57   * specify that this object will contain <b>User</b>
58   * specific properties.
59   */
60   public static final int USER = 1;
61
62  private static final String PROP_FILE_SUFFIX = ".properties";
63  private static final String DEFAULT_DESC = "Zones Property File";
64
65  /**
66   * Opens a Properties file and constructs a JASProperties object.
67   * @param
68   *   The <i>appName</i> is used in constructing the name of the
69   *   filename of the corresponding properties file. The
70   *   properties file will have a name of the form
71   *   "appName.properties"
72   * @param
73   *   type Identifies the type of properties file to open.
74   *   This parameter can have the value <b>JASProperties.USER</b>
75   *   or <b>JASProperties.SERVER</b>. The <i>type</i> parameter
76   *   controls where the properties file is opened from.
77   *
78   *   <li>User specific properties are stored in
79   *       zones.user.home\Agents directory. If the
80   *       zones.user.home System property is not defined,
81   *       user properties are stored in the
82   *       user.home\Zones\Agents directory
83   *   </li>Server specific properties are stored in
84   *       zones.home\Agents\Lib
85   *   </ul>
86   * @param
87   *   description A description of this JASProperties object.
88   *   The description will be written to the header of the
89   *   Properties file if the save method is called
90   *   createIfNecessary If set to true, the JASProperties will
91   *   create the Properties file if it does not already
92   *   exist. If set to false, then the constructor will
93   *   throw a FileNotFoundException if the Properties file
94   *   does not exist.
95   * @exception FileNotFoundException If the Properties file could not

```

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```

JASProperties.java_1    Tue Nov 12 08:01:23 1996    3

95  *
96  * @exception IOException If an error occurred while attempting to
97  *
98  * @exception IllegalArgumentException If the value passes into the
99  *
100 *
101 public JASProperties(String appName, int type, String description,
102                      boolean createIfNecessary)
103     throws FileNotFoundException, IOException, IllegalArgumentException {
104
105     itsDescription = (description != null) ? description : DEFAULT_DESC;
106
107     // Open the default JAS security properties file.
108     itsFile = locatePropertiesFile(appName, type, createIfNecessary);
109
110     loadProperties();
111 }
112
113 /**
114  * Builds an "empty" Properties object. This method can be used
115  * to construct a Properties object which returns only default values.
116  * This behavior may be desired if the Properties file can not be found
117  * and the program wishes to continue execution using its default values
118  * for preferences.
119  */
120 public JASProperties() {
121 }
122
123 /**
124  * Builds a properties filename based on the appName and properties
125  * file type
126  */
127 private File locatePropertiesFile(String appName, int type,
128                                  boolean createIfNecessary)
129     throws IllegalArgumentException, FileNotFoundException, IOException {
130
131     String propDirName;
132     if (type == SERVER) {
133         // We are accessing a server properties file.
134         // Server specific properties are stored in
135         // the directory zones.home\Agents\Lib.
136
137         propDirName = AgentConstants.AGENT_LIB_DIR;
138     } else if (type == USER) {
139         propDirName = AgentConstants.USER_AGENT_DIR;
140     } else {
141

```



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```

JASProperties.java_1      Tue Nov 12 08:01:23 1996      4
    throw new IllegalArgumentException("Bad Properties File Type: " + type);
}

// See if the properties directory exists
File propDir = new File(propDirName);
if (!propDir.exists()) {
    // The directory does not exist.
    // See if we should create it.
    if (createIfNecessary) {
        if (!propDir.mkdirs()) {
            // We could not create the directory.
            // Throw an IOException
            throw new IOException("Could create properties directory "
                                + propDir.toString());
        }
    }
} else {
    // The directory did not exist.
    // Throw a FileNotFoundException
    throw new FileNotFoundException("Properties directory "
                                + propDir.toString() + " did not exist");
}

// see if the properties file exists
File propFile = new File(propDirName + File.separator +
                        appName + PROP_FILE_SUFFIX);

if (!propFile.exists()) {
    // The directory does not exist.
    // See if we should create it.
    if (createIfNecessary) {
        // create the file.
        FileOutputStream out = new FileOutputStream(propFile);
        PrintStream print = new PrintStream(out);
        print.println("#" + itsDescription);
        print.close();
        // That should have created the file
    } else {
        // The properties file did not exist.
        // Throw a FileNotFoundException
        throw new FileNotFoundException("Properties file "
                                + propFile.toString() + " did not exist");
    }
}

return propFile;
}

```

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5

Tue Nov 12 08:01:23 1996

JASProperties.java\_1

188 )  
189  
190  
191  
192

- 34 -

```

PropertyFile.java_1      Tue Nov 12 08:01:23 1996      1
1  /*      $Header: /com/meitca/hsl/zonesjagents/shared/PropertyFile.java 2      11/11/96 5:25p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Properties (Preference) File object.
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/shared/PropertyFile.java $
13 *
14 * 2      11/11/96 5:25p Billp
15 * Made correction to company name
16 *
17 * 1      10/07/96 5:07p Walsh
18 * Initial versions
19 *
20 */
21 package com.meitca.hsl.zonesjagents.shared;
22
23 import java.io.*;
24 import java.util.*;
25
26 /**
27 * The PropertyFile object extends the behavior of the Properties class
28 * by associating the Properties with a disk file. The PropertyFile
29 * object automatically loads the Properties out of the file (using the
30 * Properties.load method) and supplies a method for saving of any updated
31 * Properties back to disk, called saveProperties.
32 * @see Properties
33 * @author Joe DiCelle
34 * @author Tom Walsh
35 */
36 public class PropertyFile extends Properties {
37
38     /** The name of the Properties file corresponding to this Properties object */
39     protected File itsFile;
40
41     /** A description of this Properties object. */
42     protected String itsDescription;
43
44     /**
45      * Opens the specified Properties file and constructs a
46      * JASProperties object.
47

```

- 35 -

```

PropertyFile.java_1      Tue Nov 12 08:01:23 1996      2

48      * @param      propertiesFileName Name of the Properties file to open
49      * @param      description A description of this JASProperties object.
50      *              The description will be written to the header of the
51      *              Properties file if the save method is called
52      * @exception      FileNotFoundException If the Properties file could not
53      *                  be found and the createIfNecessary parameter is false.
54      * @exception      IOException If an error occurred while attempting to
55      *                  access the Properties file
56      */
57      public PropertyFile(String propertiesFileName, String description)
58          throws FileNotFoundException, IOException {
59
60          itsFile = new File(propertiesFileName);
61          itsDescription = description;
62          loadProperties();
63      }
64
65      /**
66      * Protected constructor that can be used by derived classes.
67      */
68      protected PropertyFile() {
69          itsFile = null;
70          itsDescription = null;
71          // The actual work of loading properties will be
72          // done by derived class
73      }
74
75
76      // loads Properties from the Properties File
77      protected void loadProperties()
78          throws FileNotFoundException, IOException {
79
80          // open an input stream to the file specified
81          FileInputStream in = new FileInputStream(itsFile);
82
83          // load the properties
84          load(in);
85      }
86
87      /**
88      * Saves the Properties to the corresponding Properties File
89      * @exception      FileNotFoundException if the Properties file could not be
90      *                  located
91      * @exception      IOException if an error occurs while accessing the
92      *                  properties file
93      */
94      public void saveProperties()

```

```
PropertyFile.java_1      Tue Nov 12 08:01:23 1996      3

95      throws FileNotFoundException, IOException {
96
97      // open an input stream to the file specified
98      FileOutputStream out = new FileOutputStream(itsFile);
99
100     // load the properties
101     save(out, itsDescription);
102
103 }
104
105 /**
106  * Refreshes the Properties object by re-reading the Properties File. Any
107  * changes made to the Properties object will be lost.
108  * @exception FileNotFoundException if the Properties file could not be
109  *         located
110  * @exception IOException if an error occurs while accessing the
111  *         properties file
112  */
113 public void refreshProperties()
114     throws FileNotFoundException, IOException {
115     loadProperties();
116 }
117
118 }
119
120
121
122
```

```

AgentClassInfoGatherer.java_1      Tue Nov 12 07:44:46 1996      1      11/11/96 5:13p Billp $

1  /* $Header: /com/meitca/hsl/zonesjagents/bootstrap/AgentClassInfoGatherer.java 5
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * AgentClassInfoGatherer class peeks into an agents .class file to
11 * retrieve information needed for agent launching.
12 *
13 * $Log: /com/meitca/hsl/zonesjagents/bootstrap/AgentClassInfoGatherer.java $
14 * 5 11/11/96 5:13p Billp
15 * Made correction to company name.
16 *
17 * 4 9/30/96 6:35p Walsh
18 * fix up javadoc comments
19 *
20 * 3 9/27/96 6:10p Dicelle
21 * Minor change to loop which verified that the class to be launched was
22 * subclasses from Agent.
23 *
24 * 2 9/10/96 11:46a Walsh
25 * remove bogus imports that javac considers illegal
26 *
27 * 1 8/29/96 5:20p Walsh
28 * initial version
29 *
30 */
31 package com.meitca.hsl.zonesjagents.bootstrap;
32
33 import java.io.*;
34 import com.meitca.hsl.zonesjagents.conduit.AgentSkeleton;
35
36 /**
37 * This object peeks into the .class file of an agent to retrieve
38 * some information needed for launching the agent.
39 * AgentClassInfoGatherer verifies that the .class file indicated
40 * does contain a class derived from Agent and then it verifies the
41 * existence of the agent's invocation skeleton and finally loads
42 * the skeleton class into memory and retrieves a list of the
43 * agents methods from the skeleton.
44 *
45 * @see Agent
46 * @see Bootstrap
47 * @see AgentLaunchWizard

```

2

AgentClassInfoGatherer.java\_1 Tue Nov 12 07:44:46 1996

```

48  * @author      Thomas Walsh
49  */
50  public class AgentClassInfoGatherer {
51      /** The names of the agents methods */
52      String[] itsAgentsMethods;
53
54
55      /**
56       * Constructs a AgentClassInfoGatherer object. Loads the agent
57       * and its skeleton. Retrieves a list of the agent's methods.
58       * @param agentDir The directory containing the agent's
59       *                  .class file.
60       * @param agentFilename The name of the agents's .class file.
61       * @exception FileNotFoundException Thrown if the .class specified
62       *                  could not be opened.
63       * @exception IOException If an IO error occurs while trying to
64       *                  access the agent's .class file.
65       * @exception ClassFormatException If the agent's .class file does
66       *                  not contain a valid class.
67       * @exception NotAgentException If the agent's .class file does
68       *                  not contain an agent.
69       * @exception ClassNotFoundException If an error occurred while
70       *                  trying to access the agents .class file.
71       * @exception NoAgentSkeletonException If the agent's invocation
72       *                  skeleton could not be found.
73
74       */
75      public AgentClassInfoGatherer(String agentDir, String agentFilename)
76          throws FileNotFoundException, IOException, ClassFormatException,
77          NotAgentException, ClassNotFoundException,
78          NoAgentSkeletonException {
79          // let the loadAgentClassInfo method do all of the real work
80          loadAgentClassInfo(agentDir, agentFilename);
81
82      }
83
84      /**
85       * Verifies the existence and correctness of the agent .class file
86       * and the agent's skeleton. Retrieves a list of the agent's methods.
87       * Called internally by the constructor
88       * @param agentDir The directory containing the agent's
89       *                  .class file.
90       * @param agentFilename The name of the agents's .class file.
91       * @exception FileNotFoundException Thrown if the agent's .class
92       *                  did not exist.
93       * @exception IOException If an IO error occurs while trying to
94       *                  access the agent's .class file.
95       * @exception ClassFormatException If the agent's .class file does
96       *                  not contain a valid class.
97
98       */

```

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```

AgentClassInfoGatherer.java_1      Tue Nov 12 07:44:46 1996      3

95  * @exception NotAgentException If the agent's .class file does
96  *             not contain an agent.
97  * @exception ClassNotFoundException If an error occurred while
98  *             trying to access the agents .class file.
99  * @exception NotAgentSkeletonException If the agent's invocation
100  *          skeleton could not be found.
101  */
102 private void loadAgentClassInfo(String agentDir, String agentFilename)
103     throws FileNotFoundException, IOException, ClassFormatError,
104     NotAgentException, ClassNotFoundException,
105     NoAgentSkeletonException {
106
107     // load the Agent class
108     BootstrapClassLoader classLoader = new BootstrapClassLoader(agentDir);
109     Class agent = classLoader.loadAgentClassFromFile(agentFilename, true);
110
111     // verify that it is actually an Agent
112     Class superClass = agent.getSuperclass();
113
114     // STABILITY: Any way to get these hard coded strings out of here?
115     String superClassName;
116     do
117     {
118         superClassName = superClass.getName();
119         if (superClassName.equals("java.lang.Object")) {
120             throw new NotAgentException(agentFilename + " does not contain an agent");
121         }
122         superClass = superClass.getSuperclass();
123     } while (!superClassName.equals("com.meitca.hsl.zonesagents.shared.Agent"));
124
125     // ok, we have an agent.....
126     // lets try to load the skeleton
127     try {
128         // first lets strip the ".class" from the filename
129         // STABILITY: Any way to get these hard coded strings out of here?
130         String skelClassName = agentFilename.substring(0,
131             agentFilename.length() - ".class".length());
132
133         // append on the _Skel
134         skelClassName = skelClassName + "_Skel.class";
135
136         // now try to load the skeleton class
137         Class skelClass = classLoader.loadAgentClassFromFile(skelClassName, true);
138
139         // finally retrieve the agents methods.
140
141

```



```
AgentClassInfoGatherer.java_1      Tue Nov 12 07:44:46 1996      4

142      AgentSkeleton skel = (AgentSkeleton)skelClass.newInstance();
143      itsAgentsMethods = skel.getMethods();
144      ) catch (Exception e) {
145          throw new ClassNotFoundException("Could not find skeleton for agent " + agentFilename);
146      }
147  }
148
149  /**
150   * Retrieves a list of the agents methods. This list is used
151   * by the Agent Launch GUI in order to present the user with
152   * a drop down list containing the eligible methods of the agent.
153   */
154  public String[] getAgentsMethods() {
155      return itsAgentsMethods;
156  }
157 }
```

```

AgentLaunchInformation.java_1      Tue Nov 12 07:44:46 1996      1      11/11/96 5:13p Billp $

1  /* $Header: /com/meitca/hsl/zonesjagents/bootstrap/AgentLaunchInformation.java 4
2
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8
9  * DESCRIPTION
10  * AgentLaunchInformation encapsulates the information needed to
11  * bootstrap the agent into the system.
12
13  * $Log: /com/meitca/hsl/zonesjagents/bootstrap/AgentLaunchInformation.java $
14
15  * 4 11/11/96 5:13p Billp
16  * Made correction to company name.
17
18  * 3 9/30/96 6:35p Walsh
19  * fix up javadoc comments
20
21  * 2 9/11/96 4:46p Walsh
22  * add itsAgent member
23
24  * 1 8/23/96 5:21p Walsh
25  * initial version
26
27  */
28 package com.meitca.hsl.zonesjagents.bootstrap;
29
30 import com.meitca.hsl.zonesjagents.conduit.Itinerary;
31 import com.meitca.hsl.zonesjagents.shared.Agent;
32
33
34 /**
35  * The AgentLaunchInformation class encapsulates the information
36  * needed by the Bootstrap class in order to launch and Agent.
37  * This class is used internally by the AgentLaunchWizard and
38  * the Agent command line launch tool.
39  * @see Agent
40  * @see Bootstrap
41  * @see AgentLaunchWizard
42  * @author Thomas Walsh
43  */
44 public class AgentLaunchInformation {
45     /**
46      * The directory (on the local host) containing the agent's
47      * .class file as well as the .class files of any related

```

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AgentLaunchInformation.java\_1 Tue Nov 12 07:44:46 1996 2

```

48  * classes.
49  */
50  public String      itsAgentDirectory;
51
52  /** The agent's .class file */
53  public String      itsAgentFile;
54
55  /**
56   * An array containing the filenames of any other classes
57   * that should be sent along with the agent. The ConduitServer
58   * has the ability to communicate back to the agents home machine
59   * to retrieve classes needed at runtime (if the RemoteLoader server
60   * is running). With this parameter a programmer can bypass this
61   * and send any needed classes up front.
62  */
63  public String[]    itsRelatedClasses;
64
65  /** The agents Itinerary */
66  public Itinerary   itsItinerary;
67
68  /**
69   * The agent itself. This member on needs to be filled in if the
70   * caller wants to call a method on the agent other than the default
71   * constructor. If this field is left blank, then the
72   * Bootstrap.launchAgent method will construct the Agent contained in
73   * the file itsAgentDirectory by calling its default constructor.
74   * This method gives the programmer the option of constructing an
75   * agent with a ctor other than the default.
76  */
77  public Agent       itsAgent;
78
79  /**
80   * A listing of the agents methods. This member variable need not
81   * be filled in in order to launch the agent, but is used internally
82   * by the AgentLaunchWizard
83  */
84  public String[]    itsMethods;
85
86  /** Constructs an empty AgentLaunchInformation object */
87  public AgentLaunchInformation() {
88      itsAgentDirectory = new String("");
89      itsAgentFile = new String("");
90      itsItinerary = new Itinerary();
91      itsAgent = null;
92  }
93  )

```

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```

AgentLaunchWizard.java_1      Tue Nov 12 07:44:46 1996      1
1 /* $Header: /ccm/meitca/hsl/zonesagents/bootstrap/AgentLaunchWizard.java 10 11/11/96 5:13p Billp $
2 *
3 * Copyright 1996 Horizon Systems Laboratory,
4 * Mitsubishi Electric Information Technology Center America.
5 * All rights reserved.
6 *
7 * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8 *
9 * DESCRIPTION
10 * GUI tool for launching agents into system
11 *
12 * $Log: /ccm/meitca/hsl/zonesagents/bootstrap/AgentLaunchWizard.java $
13 *
14 * 10 11/11/96 5:13p Billp
15 * Made correction to company name.
16 *
17 * 9 10/10/96 5:57p Walsh
18 * Make use of properties in AgentConstants class
19 *
20 * 8 10/08/96 10:21a Walsh
21 * Fix name collision between bootstrap.StringResources and
22 * util.StringResources
23 *
24 * 7 10/07/96 4:44p Walsh
25 * Save name & location of last agent launched. Restart Wizard pointing
26 * at same agent.
27 *
28 * 6 10/07/96 3:55p Walsh
29 * Set up case to look in zones.home\images for GIF file
30 *
31 * 5 9/31/96 6:35p Walsh
32 * fix up javadoc comments
33 *
34 * 4 9/27/96 11:52a Walsh
35 * print exception to stderr on LaunchException
36 *
37 * 3 9/09/96 3:46p Walsh
38 * replace gjt.MessageDialog with com.meitca.hsl.util.InfoDialog. Create
39 * Security Manager in main
40 *
41 * 2 9/04/96 12:34p Walsh
42 * Pop up dialog on any problems launching the agent
43 *
44 * 1 8/23/96 5:21p Walsh
45 * initial version
46 *
47 */

```

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AgentLaunchWizard.java\_1      Tue Nov 12 07:44:46 1996      2

```

48 package com.meitca.hsl.zonesjagents.bootstrap;
49
50 import java.awt.*;
51 import java.io.*;
52 import java.util.*;
53
54 import com.meitca.hsl.util.*;
55 import com.meitca.hsl.zonesjagents.security.*;
56 import com.meitca.hsl.zonesjagents.shared.*;
57
58 /**
59  * The AgentLaunchWizard provides a wizard-like GUI for launching
60  * Java Agents into the system
61  * @see Agent
62  * @see Bootstrap
63  * @see AgentLaunchInformation
64  * @see Wizard
65  * @author Thomas Walsh
66  */
67 public class AgentLaunchWizard extends Wizard {
68     /** The launch information */
69     AgentLaunchInformation itsAgentInfo;
70
71     /** The filename of the GIF */
72     static final String GIF_FILENAME = AgentConstants.IMAGE_DIR + "AgentLaunchWizard.gif";
73
74     /** Properties (Preference) object */
75     JASProperties itsProperties;
76
77     static final String LAST_AGENT_DIR="zones.agent.bootstrap.LastAgentDir";
78     static final String LAST_AGENT_FILE="zones.agent.bootstrap.LastAgentFile";
79     // Static initializer
80
81     /**
82      * Constructs an AgentLaunchWizard object. Brings up the GUI and
83      * sets up the first panel.
84      */
85     public AgentLaunchWizard() {
86         super(com.meitca.hsl.zonesjagents.bootstrap.StringResources.WIZARD_TITLE,
87             GIF_FILENAME);
88         itsAgentInfo = new AgentLaunchInformation();
89
90         try {
91             itsProperties = new JASProperties(
92                 com.meitca.hsl.zonesjagents.bootstrap.StringResources.WIZARD_APPNAME,
93                 JASProperties.USER,
94                 com.meitca.hsl.zonesjagents.bootstrap.StringResources.PROP_DESC,

```

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AgentLaunchWizard.java\_1 Tue Nov 12 07:44:46 1996 3

```

95         true);
96     } catch (Exception e) {
97         itsProperties = null;
98     }
99
100     if (itsProperties != null) {
101         itsAgentInfo.itsAgentDirectory = itsProperties.getProperty(LAST_AGENT_DIR, "");
102         itsAgentInfo.itsAgentFile = itsProperties.getProperty(LAST_AGENT_FILE, "");
103     }
104
105     buildPanels();
106     firstPanel();
107
108     resize(570, 370);
109     show();
110 }
111
112 /**
113  * Builds the panels of the wizard. The AgentLaunchWizard
114  * contains three panels 1) a panel for specifying the agent's class
115  * file (names FindFilePanel), 2) a panel for specifying the related
116  * class files for sending with the agent (called RelatedFilesPanel) and
117  * 3) a panel for setting up the agents itinerary (called ItineraryPanel)
118  */
119 protected void buildPanels() {
120     FindFilePanel panel1 = new FindFilePanel(this, itsAgentInfo);
121     RelatedFilesPanel panel2 = new RelatedFilesPanel(this, itsAgentInfo);
122     ItineraryPanel panel3 = new ItineraryPanel(this, itsAgentInfo);
123 }
124
125 /**
126  * The finish method is called by the Wizard base class when the
127  * user has successfully filled all the necessary information
128  * into all the panels and has pressed the "Finish" button. We now
129  * have all of the information we need so we'll try to launch the agent.
130  */
131 protected void finish() {
132     try {
133         // launch the agent
134         BootStrap.launchAgent(itsAgentInfo);
135
136         if (itsProperties != null) {
137             try {
138                 itsProperties.put(LAST_AGENT_DIR, itsAgentInfo.itsAgentDirectory);
139                 itsProperties.put(LAST_AGENT_FILE, itsAgentInfo.itsAgentFile);
140                 itsProperties.saveProperties();
141             } catch (Exception e) {

```

```

AgentLaunchWizard.java_1      Tue Nov 12 07:44:46 1996      4

142         }
143     }
144
145     // shutdown.
146     cancel();
147
148     ; catch (LaunchException e) {
149         InfoDialog info = new InfoDialog(this,
150             com.meitca.hsl.zonesjagents.bootstrap.StringResources.LAUNCH_ERROR_TITLE,
151             com.meitca.hsl.zonesjagents.bootstrap.StringResources.LAUNCH_ERROR);
152         info.setBackground(Color.lightGray);
153         info.show();
154
155         System.err.println(e.getMessage());
156         e.printStackTrace();
157     }
158
159     /**
160     * main routine supplied so that AgentLaunchWizard can be initiated
161     * from the command line
162     */
163     public static void main(String args[]) {
164         // Create and install the security manager
165         System.setSecurityManager(new InsecurityManager());
166
167         AgentLaunchWizard gui = new AgentLaunchWizard();
168     }
169
170 )

```

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```

AgentLaunchWizardPanel.java_1      Tue Nov 12 07:44:47 1996      1      11/11/96 5:13p Billp $

1  /* $Header: /com/meitca/hsl/zonesjagents/bootstrap/AgentLaunchWizardPanel.java 4
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * A subclass of WizardPanel for use in the AgentLaunchWizard
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/bootstrap/AgentLaunchWizardPanel.java $
13  *
14  * 4 11/11/96 5:13p Billp
15  * Made correction to company name.
16  *
17  * 3 9/30/96 6:35p Walsh
18  * fix up javadoc comments
19  *
20  * 2 9/10/96 11:46a Walsh
21  * remove bogus imports that javac considers illegal
22  *
23  * 1 8/29/96 5:21p Walsh
24  * initial version
25  *
26  */
27 package com.meitca.hsl.zonesjagents.bootstrap;
28
29 import java.awt.*;
30
31 import com.meitca.hsl.util.Wizard;
32 import com.meitca.hsl.util.WizardPanel;
33
34
35 /**
36  * AgentLaunchWizardPanel is a base class for the panels of the
37  * AgentLaunchWizard. All of the panels in the launch wizard need
38  * shared access to the AgentLaunchInformation object describing the
39  * parameters of the launch. This base class provides that
40  * access.
41  * @see Agent
42  * @see Bootstrap
43  * @see AgentLaunchInformation
44  * @see AgentLaunchWizard
45  * @author Thomas Walsh
46  */
47 public class AgentLaunchWizardPanel extends WizardPanel {

```



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```
AgentLaunchWizardPanel.java_1      Tue Nov 12 07:44:47 1996      2

48  /** The launch parameters of the Wizard*/
49  protected AgentLaunchInformation  itsAgentInfo;
50
51  /**
52   * Constructs an AgentLaunchWizardPanel.
53   * @param wizard The Wizard owning this panel (needed by super)
54   * @param info The (shared) reference to the agent launch information
55   */
56  public AgentLaunchWizardPanel(Wizard wizard, AgentLaunchInformation info) {
57      super(wizard);
58      itsAgentInfo = info;
59  }
60
61 }
```

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```

Bootstrap.java_1      Tue Nov 12 07:44:47 1996      1
1  /* $Header: /com/meitca/hsl/zonesagents/bootstrap/Bootstrap.java 11 11/11/96 5:13p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Module for boot strapping agents into the system.
11  *
12  * $Log: /com/meitca/hsl/zonesagents/bootstrap/Bootstrap.java $
13  *
14  * 11 11/11/96 5:13p Billp
15  * Made correction to company name.
16  *
17  * 10 10/01/96 10:39a Walsh
18  * fix @exception javadoc tag
19  *
20  * 9 9/30/96 7:33p Walsh
21  * add more javadoc
22  *
23  * 8 9/28/96 6:56p Walsh
24  * Add new version of launchAgent
25  *
26  * 7 9/11/96 4:59p Walsh
27  * allow launchInfo.itsRelatedClasses to be null
28  *
29  * 6 9/11/96 4:46p Walsh
30  * if caller specified LaunchInfo.itsAgent, use that rather than
31  * constructing a new one.
32  *
33  * 5 9/10/96 11:46a Walsh
34  * remove bogus imports that javac considers illegal
35  *
36  * 4 9/09/96 3:46p Walsh
37  * Move creation of SecurityManager to main to prevent error on multiple
38  * calls to Launch
39  *
40  * 3 9/05/96 6:38p Walsh
41  * Add a main method to handle command line agent launching
42  *
43  * 2 9/04/96 12:35p Walsh
44  * Add some exception handling. Let ConduitServer handle details of
45  * launching agent. Let RemoteLoader build up the home codebase URL
46  *
47  * 1 8/29/96 5:21p Walsh

```

- 50 -

Bootstrap.java\_1 Tue Nov 12 07:44:47 1996 2

```

48 * initial version
49 *
50 */
51 package com.meitca.hsl.zones.agents.bootstrap;
52
53 import java.rmi.Naming;
54 import java.rmi.server.StubSecurityManager;
55 import java.rmi.server.MarshalOutputStream;
56 import java.net.InetAddress;
57 import java.util.*;
58 import java.io.*;
59
60 import com.meitca.hsl.zones.agents.shared.*;
61 import com.meitca.hsl.zones.agents.conduit.ConduitServer;
62 import com.meitca.hsl.zones.agents.conduit.AgentPackage;
63 import com.meitca.hsl.zones.agents.conduit.Itinerary;
64 import com.meitca.hsl.zones.agents.conduit.MobileCodebase;
65 import com.meitca.hsl.zones.agents.conduit.ConduitObjectOutputStream;
66 import com.meitca.hsl.zones.agents.conduit.Destination;
67 import com.meitca.hsl.zones.agents.conduit.ConduitServerImpl;
68 import com.meitca.hsl.zones.agents.remoteloader.RemoteClassLoaderImpl;
69 import com.meitca.hsl.zones.agents.security.InsecurityManager;
70
71
72
73 /**
74  * Bootstrap provides a mechanism for boot strapping (launching) agents
75  * into the system. The calling program must provide the launch parameters
76  * in the form of the AgentLaunchInformation object. Bootstrap takes this
77  * information and provides the necessary steps to launch the indicated agents.
78  * This includes building creating the MobileCodebase, loading any needed
79  * classes (including the agent) into the MobileCodebase, constructing the
80  * AgentPackage, contacting the initial ConduitServer and sending the agent.
81  * @see Agent
82  * @see AgentLaunchInformation
83  * @author Thomas Walsh
84  */
85 public class Bootstrap {
86     /**
87      * Launches an agent.
88      * @param agent The agent to launch
89      * @param itinerary The agent's itinerary
90      * @param agentCodebaseURL An URL pointing to the codebase of the agent.
91      * This URL can take the following forms:
92      * <ul>
93      * <li>A file URL like <b>file:C:\agents\</b> - which indicates that the
94      * agent's code is located on the local machine in the directory

```

```

BootStrap.java_1      Tue Nov 12 07:44:47 1996      3

    *
    *      <b>C:\agent</b>
    *      <li>An HTTP URL like <b>http://hostname/agents</b> - which indicates a
    *      location on a web server from which the agents code can be
    *      retrieved. (This is very similar to the codebase modifier
    *      which can be added to an HTML <b><altaplet></b> tag).
    *      <li>An RMI URL like <b>rmi://hostname/RemoteClassLoader</b> pointing
    *      to a RemoteClassLoader object which can retrieve the agents code.<br>
    *      This RMI URL could also look like
    *      <b>rmi://hostname/RemoteClassLoader/C:\agents</b> which indicates that
    *      the RemoteClassLoader on hostname should be used to retrieve
    *      the classes and that the agents code is located in the <b>C:\agents</b>
    *      directory.
    *
    *      </ul>
    *      @param      relatedClasses An array of fully qualified classnames of classes which this agent makes
    *      use of. These classes will be set up to travel with the agent.
    *      @exception  LaunchException is the agent could not be launched.
    */
    public static void launchAgent(Agent agent, Itinerary itinerary, String agentCodebaseURL,
    String[] relatedClasses) throws LaunchException
    {
        try {
            MobileCodebase agentCode = new MobileCodebase();
            BootStrapClassLoader bootStrap = new BootStrapClassLoader(agentCodebaseURL,
            agentCode);
            bootStrap.loadAgentClass(agent.getClass().getName(), false);
            if (relatedClasses != null) {
                for (int i=0; i<relatedClasses.length; i++)
                    Class related = bootStrap.loadAgentClass(relatedClasses[i], false);
            }
            String absoluteCodebaseURL;
            if (agentCodebaseURL != null) {
                if (!agentCodebaseURL.startsWith("rmi:") && !agentCodebaseURL.startsWith("http:"))
                    if (agentCodebaseURL.startsWith("file:")) {
                        absoluteCodebaseURL = RemoteClassLoaderImpl.buildCodebaseURL(
                            InetAddress.getLocalHost().getHostAddress(),
                            agentCodebaseURL.substring(7));
                    } else {
                        absoluteCodebaseURL = RemoteClassLoaderImpl.buildCodebaseURL(
                            InetAddress.getLocalHost().getHostAddress(),
                            agentCodebaseURL);
                    }
            }
            try {
                agentCode.setHostAddress(absoluteCodebaseURL);
            } catch (Exception e) {
                // ignore
            }
        } catch (Exception e) {
            // ignore
        }
    }

```

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```

Bootstrap.java_1      Tue Nov 12 07:44:47 1996      4

137         } else {
138             absoluteCodebaseURL = agentCodebaseURL;
139         }
140     } else {
141         absoluteCodebaseURL = RemoteClassLoaderImpl.buildRmiURL(
142             InetAddress.getLocalHost().get
143         )
144     }
145     AgentPackage agentPackage = new AgentPackage(agent
146     ,
147     ,
148     ,
149     ,
150     ,
151     ,
152     ,
153     ,
154     ,
155     ,
156     ,
157     ,
158     ,
159     ,
160     ,
161     ,
162     ,
163     ,
164     ,
165     ,
166     ,
167     ,
168     ,
169     ,
170     ,
171     ,
172     ,
173     ,
174     ,
175     ,
176     ,
177     ,

// pass the agent along
ConduitServerImpl.sendPackage(agentPackage);

} catch (Exception error) {
    throw new LaunchException("LaunchException: " + error.getMessage());
}

}

/**
 * Launches an agent based on the given launch parameters
 * @param launchInfo The launch parameters
 */
public static void launchAgent(AgentLaunchInformation launchInfo) throws LaunchException {
    try {
        MobileCodebase agentCode = new MobileCodebase();
        BootstrapClassLoader bootstrap = new BootstrapClassLoader(launchInfo.itsAgentDirectory,
            launchInfo.itsRelatedClasses, launchInfo.itsRelatedClasses.length);
        Class agentClass = bootstrap.loadAgentClassFromFile(launchInfo.itsAgentFile, true);
        if (launchInfo.itsRelatedClasses != null) {
            for (int i=0; i<launchInfo.itsRelatedClasses.length; i++)
                Class related = bootstrap.loadAgentClassFromFile(launchInfo.itsRelatedClasses[i], true);
        }
        String codebaseURL = RemoteClassLoaderImpl.buildCodebaseURL(
            InetAddress.getLocalHost().getHostN

```

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```

Bootstrap.java_1      Tue Nov 12 07:44:47 1996      5

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220

        launchInfo.itsAgentDirectory);

        Agent agent;
        if (launchInfo.itsAgent == null) {
            agent = (Agent)agentClass.newInstance();
        } else {
            agent = launchInfo.itsAgent;
        }
        AgentPackage agentPackage = new AgentPackage(agent,
            Code,
            hInfo.itsItinerary,
            aseURL);

        // pass the agent along
        ConduitServerImpl.sendPackage(agentPackage);

        } catch (Exception error) {
            throw new LaunchException("LaunchException: " + error.getMessage());
        }

    }

    /**
     * This method gets invoked when a user tries to launch an Agent from
     * the command line. The command line should look something like the
     * following:<br>
     * <pre>
     * Usage: bootstrap [-d hostname.method] [-f relatedfile.class] [-h] agentfile.class
     * </pre><br>
     * The user specifies the agent class file as the last parameter to
     * the command. The destinations for the Agent are specified with the
     * <b>-d</b> option. A destination is specified by the hostname follows by a
     * comma (no space) followed by the name of the method to invoke.
     * This could look something like the following; <b>-d host1.agentMethod1</b>.
     * The user specifies related class files that should be sent with the
     * agent using the <b>-f</b> option. Finally, the <b>-h</b> option brings up
     * some command line help.
     */
    public static void main(String args[]) {
        // Create and install the security manager

```

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Bootstrap.java\_1

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```

221 System.setSecurityManager(new InsecurityManager());
222
223 // We start by doing some rather brute force parsing of the
224 // command line. The command line args are used to build up
225 // an AgentLaunchInformation data structure.
226 AgentLaunchInformation launchInfo = new AgentLaunchInformation();
227 Vector destinationStrings = new Vector();
228 Vector relatedFiles = new Vector();
229 String agentFile = null;
230
231 for (int i=0; i<args.length; i++) {
232     if (args[i].equals("-d")) {
233         String destinationString = args[++i];
234         destinationStrings.addElement(destinationString);
235         continue;
236     } else if (args[i].equals("-f")) {
237         String fileName = args[++i];
238         relatedFiles.addElement(fileName);
239         continue;
240     } else if (args[i].equals("-h")) {
241         System.out.println(StringResources.USAGE);
242         return;
243     } else {
244         if (args[i].charAt(0) == '-') {
245             System.out.println(StringResources.ILLEGAL_OPTN + args[i]);
246             return;
247         } else {
248             agentFile = args[i];
249         }
250     }
251 }
252
253 // first lets verify that we have a valid agent file.
254 if (agentFile == null) {
255     System.out.println(StringResources.NO_AGENT);
256     System.out.println(StringResources.USAGE);
257     return;
258 }
259
260 if (!agentFile.endsWith(".class")) {
261     System.out.println(StringResources.ILLEGAL_AGENT + agentFile);
262     System.out.println(StringResources.AGENT_HELP);
263     return;
264 }
265
266 launchInfo.setAgentDirectory = new String("");
267

```

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BootStrap.java\_1

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7

```

268   launchInfo.itsAgentFile = agentFile;
269
270   for (int i=agentFile.length()-1; i>=0; i--) {
271       if (agentFile.charAt(i) == File.separatorChar ) {
272           launchInfo.itsAgentDirectory = agentFile.substring(0, i+1);
273           launchInfo.itsAgentFile = agentFile.substring(i+1, agentFile.length());
274           break;
275       }
276   }
277
278   // Now let the AgentClassInfoGatherer verify the existence of the file,
279   // that the file contains a valid Java Agent and that the skeleton
280   // exists.
281   try {
282       AgentClassInfoGatherer agentInfoGatherer = new AgentClassInfoGatherer(
283           launchInfo.itsAgentDirectory, launchInfo.itsAgentFile);
284
285       launchInfo.itsMethods = agentInfoGatherer.getAgentMethods();
286       catch (FileNotFoundException e) {
287           System.out.println(StringResources.ILLEGAL_AGENT + agentFile);
288           System.out.println("\t" + StringResources.FILE_NOTFOUND);
289           return;
290       } catch (IOException e) {
291           System.out.println(StringResources.ILLEGAL_AGENT + agentFile);
292           System.out.println("\t" + StringResources.IOERROR);
293           return;
294       } catch (ClassFormatError e) {
295           System.out.println(StringResources.ILLEGAL_AGENT + agentFile);
296           System.out.println("\t" + StringResources.BAD_CLASS_FORMAT);
297           return;
298       } catch (NotAgentException e) {
299           System.out.println(StringResources.ILLEGAL_AGENT + agentFile);
300           System.out.println("\t" + StringResources.NOT_AGENT);
301           return;
302       } catch (ClassNotFoundException e) {
303           System.out.println(StringResources.ILLEGAL_AGENT + agentFile);
304           System.out.println("\t" + StringResources.BAD_CLASS_FORMAT);
305           return;
306       } catch (NoAgentSkeletonException e) {
307           System.out.println(StringResources.ILLEGAL_AGENT + agentFile);
308           System.out.println("\t" + StringResources.NO_SKELETON);
309           return;
310       }
311
312   // Lets take a look at the related files
313   launchInfo.itsRelatedClasses = new String[relatedFiles.size()];
314   for (int i=0; i< relatedFiles.size(); i++) {

```



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```

BootStrap.java_1      Tue Nov 12 07:44:47 1996      8

315 String fileName = (String)relatedFiles.elementAt(i);
316 if (fileName.endsWith(".class")) {
317     launchInfo.itsRelatedClasses[i] = fileName;
318 } else {
319     System.out.println(StringResources.ILLEGAL_RELFILE + fileName);
320     System.out.println(StringResources.RELFILE_HELP);
321     return;
322 }
323
324 // Finally, lets take a look at those destinations
325 if (destinationStrings.size() == 0) {
326     System.out.println(StringResources.NO_DEST);
327     return;
328 }
329
330 for (int i=0; i<destinationStrings.size(); i++) {
331     String destinationString = (String)destinationStrings.elementAt(i);
332     StringTokenizer tokenizer = new StringTokenizer(destinationString, ",");
333
334     if (tokenizer.countTokens() != 2) {
335         System.out.println(StringResources.ILLEGAL_DEST + destinationString);
336         System.out.println(StringResources.USAGE);
337     }
338
339     String hostname = tokenizer.nextToken();
340     String methodname = tokenizer.nextToken();
341
342     // find out if the methodname actually point to one of the methods
343     // in the Agent
344     int methodId = -1;
345     for(int j=0; j<launchInfo.itsMethods.length; j++) {
346         if (launchInfo.itsMethods[j].equals(methodname)) {
347             methodId = j;
348         }
349     }
350
351     if (methodId == -1) {
352         System.out.println(StringResources.ILLEGAL_METHOD + methodname);
353         System.out.println(StringResources.USAGE);
354         return;
355     } else {
356         launchInfo.itsItinerary.addDestination(new Destination(hostname, methodId));
357     }
358 }
359
360 // now that we have parsed the command line and built up the
361

```

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```
BootStrap.java_1
362
363
364
365
366
367
368
369
370 )

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// launchInfo, we will actually attempt to launch the agent.
try {
    launchAgent(launchInfo);
} catch (LaunchException e) {
    System.out.println(StringResources.LAUNCH_ERROR + ": " + e.getMessage());
    e.printStackTrace();
}
```

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```

BootstrapClassLoader.java_1      Tue Nov 12 07:44:47 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/bootstrap/BootstrapClassLoader.java 3 11/11/96 5:13p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * ClassLoader used in agent bootstrap process.
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/bootstrap/BootstrapClassLoader.java $
13 *
14 * 3 11/11/96 5:13p Billp
15 * Made correction to company name.
16 *
17 * 2 9/28/96 6:56p Walsh
18 * Use AgentCodebase object to retrieve bytecodes.
19 *
20 * 1 8/29/96 5:21p Walsh
21 * Initial version
22 *
23 */
24 package com.meitca.hsl.zonesjagents.bootstrap;
25
26 import java.io.*;
27 import java.net.*;
28 import java.rmi.Naming;
29
30 import com.meitca.hsl.zonesjagents.conduit.*;
31 import com.meitca.hsl.zonesjagents.shared.*;
32 import com.meitca.hsl.zonesjagents.remoteloader.*;
33
34
35 /**
36 * BootstrapClassLoader is used internally by the Bootstrap
37 * class to load agent related classes
38 * @see Agent
39 * @see Bootstrap
40 * @see MobileCodebase
41 * @author Thomas Walsh
42 */
43 public class BootstrapClassLoader extends ClassLoader {
44     /** An URL pointing to the cobase from which class files should be retrieved */
45     String itsHomeCodebaseURL;
46
47     /** An object representing the home codebase of the agent */

```

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BootstrapClassLoader.java\_1 Tue Nov 12 07:44:47 1996 2

```

48. AgentCodebase itsHomeCodebase;
49.
50. /** The mobile code base into which to load classes */
51. MobileCodebase itsMobileCodebase;
52.
53. /**
54.  * object which actually handles the dirty work or retrieving .class
55.  * files for a given class.
56.  */
57. ClassFileLoader
58.     itsClassFileLoader;
59.
60. /**
61.  * Constructs a BootstrapClassLoader.
62.  * @param url The directory from which this ClassLoader should
63.  *           retrieve .class files
64.  */
65. public BootstrapClassLoader(String url) throws MalformedURLException {
66.     itsHomeCodebaseURL = url;
67.     itsHomeCodebase = new AgentCodebase(url);
68.     itsMobileCodebase = null;
69.     itsClassFileLoader = new ClassFileLoader();
70. }
71.
72. /**
73.  * Constructs a BootstrapClassLoader. When this constructor is
74.  * called, the ClassLoader realizes that their is an associated
75.  * MobileCodebase object. As .class files are read from disk,
76.  * they are also written into the MobileCodebase. Once they are
77.  * loaded into the MobileCodebase, they are ready to travel.
78.  * @param dir The directory from which this ClassLoader should
79.  *           retrieve .class files
80.  * @param codebase The associated MobileCodebase object
81.  */
82. public BootstrapClassLoader(String url, MobileCodebase codebase) throws MalformedURLException {
83.     this(url);
84.     itsMobileCodebase = codebase;
85. }
86.
87. /**
88.  * Load a class. The classes .class file must be in the directory
89.  * that was specified in the constructor. If a MobileCodebase
90.  * was specified in the constructor, the class will also be loaded
91.  * into that codebase.
92.  * @param name The class name
93.  * @param resolve True if resolveClass should be called
94.  */

```

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```

BootstrapClassLoader.java_1      Tue Nov 12 07:44:47 1996      3

95     public Class loadAgentClass(String name, boolean resolve) throws ClassNotFoundException {
96
97         byte[] bytecodes = itsHomeCodebase.retrieveCode(name);
98
99         Class c = defineClass(bytecodes, 0, bytecodes.length);
100         if (resolve)
101             resolveClass(c);
102
103         if (itsMobileCodebase != null)
104             itsMobileCodebase.storeCode(c.getName(), bytecodes);
105
106         return c;
107     }
108
109     /**
110     * Load a class from the specified file. The file must be in the
111     * directory that was specified in the constructor. If a
112     * MobileCodebase was specified in the constructor, the class will
113     * also be loaded into that codebase.
114     * @param name The class filename
115     * @param resolve True if resolveClass should be called
116     */
117     //STABILITY: Integrate this method with loadAgentClass
118     public Class loadAgentClassFromFile(String fileName, boolean resolve)
119         throws FileNotFoundException, IOException, ClassNotFoundException, ClassFormatError {
120
121         File file = new File(itsHomeCodebaseURL, fileName);
122         long length = file.length();
123         FileInputStream stream = new FileInputStream(file);
124         byte data[] = new byte[(int)length];
125
126         stream.read(data);
127         Class c = defineClass(data, 0, (int)length);
128         if (resolve) {
129             resolveClass(c);
130         }
131
132         if (itsMobileCodebase != null)
133             itsMobileCodebase.storeCode(c.getName(), data);
134
135         return c;
136     }
137
138     /**
139     * The java.lang.ClassLoader version of loadClass.
140     * First looks for a standard system class, and then looks for an
141     * agent class in the directory that was specified in the constructor.
142     * If the class is an Agent related class, then its bytecodes are

```

```

BootstrapClassLoader.java_1      Tue Nov 12 07:44:47 1996      4

142      * loaded into the MobileCodebase
143      * @param      name The class name
144      * @param      resolve True if resolveClass should be called
145      */
146      protected Class loadClass(String name, boolean resolve) throws ClassNotFoundException {
147          try {
148              Class c = findSystemClass(name);
149              if (!resolve) {
150                  resolveClass(c);
151              }
152              return c;
153          } catch (ClassNotFoundException e1) {
154              try {
155                  return loadAgentClass(name, resolve);
156              } catch (Exception e2) {
157                  throw new ClassNotFoundException("Could not load " + name);
158              }
159          }
160      }
161  }

```

```

FindFilePanel.java_1      Tue Nov 12 07:44:47 1996      1      11/11/96 5:13p Billp S
1  /*      $Header: /com/meitca/hsl/zonesjagents/bootstrap/FindFilePanel.java 5
2  *
3  *      Copyright 1996 Horizon Systems Laboratory,
4  *      Mitsubishi Electric Information Technology Center America.
5  *      All rights reserved.
6  *
7  *      CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  *      DESCRIPTION
10  *      The FindFilePanel of the AgentLaunchWizard
11  *
12  *      $Log: /com/meitca/hsl/zonesjagents/bootstrap/FindFilePanel.java 5
13  *
14  *      5      11/11/96 5:13p Billp
15  *      Made correction to company name.
16  *
17  *      4      10/07/96 4:44p Walsh
18  *      Save name & location of last agent launched. Restart Wizard pointing
19  *      at same agent.
20  *
21  *      3      9/10/96 11:46a Walsh
22  *      remove bogus imports that javac considers illegal
23  *
24  *      2      9/09/96 3:45p Walsh
25  *      replace gjt.MessageDialog w/ com.meitca.hsl.util.InfoDialog
26  *
27  *      1      8/29/96 5:21p Walsh
28  *      intial version
29  *
30  */
31 package com.meitca.hsl.zonesjagents.bootstrap;
32
33 import java.awt.*;
34 import java.io.*;
35 import gjt.Util;
36
37 import com.meitca.hsl.util.Wizard;
38 import com.meitca.hsl.util.WizardPanel;
39 import com.meitca.hsl.util.InfoDialog;
40
41 /**
42  * the first panel of the AgentLaunchWizard. This panel allows the user
43  * to specify the filename of the .class file containing the agent.
44  * @see Agent
45  * @see AgentLaunchWizardPanel
46  * @see AgentLaunchWizard
47  * @author Thomas Walsh

```

FindFilePanel.java\_1 Tue Nov 12 07:44:47 1996 2

```

48 */
49 public class FindFilePanel extends AgentLaunchWizardPanel {
50 /** The edit field */
51 TextField
52
53 /** The "Browse..." button */
54 Button
55
56 /**
57 * Construct the FindFilePanel and all of its components.
58 * @param wizard The wizard to which this panel belongs (needed by
59 * super)
60 * @param wiinfozard The AgentLaunchInformation describing this
61 * agent launch (needed by super)
62 */
63 public FindFilePanel(Wizard wizard, AgentLaunchInformation info) {
64     super(wizard, info);
65     buildPanel();
66 }
67
68 /**
69 * Verify that the information entered into the panel is valid. Called
70 * after the "Next >" button is pressed.
71 *
72 * The method validates the following things...
73 *
74 * 1) A class file name is specified
75 * 2) The file name ends with ".class"
76 * 3) The file exists
77 * 4) The file contains valid Java bytecodes
78 * 5) The file contains a class derived from Agent
79 * 6) An invocation skeleton is available.
80 * @returns true if the panel contains valid info, false if not
81 */
82 public boolean validatePanel() {
83     // we want to break the full filename up into the directory portion
84     // and the filename portion. Find the last occurrence of the
85     // directory separator character
86     String fullName = itsFileBrowseField.getText();
87
88     // Verify that someone typed something into the edit control and that
89     // what they typed in ends with .class
90     if (fullName.length() == 0) {
91         InfoDialog info = new InfoDialog(itsWizard,
92             StringResources.LAUNCH_ERROR_TITLE,
93             StringResources.NO_FILENAME);
94         info.setBackground(Color.lightGray);
95         info.show();
96     }

```



FindFilePanel.java\_1

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```

95         return false;
96     }
97
98     if (!fullName.endsWith(".class")) {
99         InfoDialog info = new InfoDialog(itsWizard,
100             StringResources.LAUNCH_ERROR_TITLE,
101             StringResources.ENDSWITH_CLASS);
102         info.setBackground(Color.lightGray);
103         info.show();
104         return false;
105     }
106
107     itsAgentInfo.itsAgentDirectory = new String("");
108     itsAgentInfo.itsAgentDirectory = fullName;
109
110     for (int i=fullName.length()-1; i>=0; i--) {
111         if (fullName.charAt(i) == File.separatorChar) {
112             itsAgentInfo.itsAgentDirectory = fullName.substring(0, i+1);
113             itsAgentInfo.itsAgentFile = fullName.substring(i+1, fullName.length());
114             break;
115         }
116     }
117
118     // Now let the AgentClassInfoGatherer verify the existence of the file,
119     // that the file contains a valid Java Agent and that the skeleton
120     // exists.
121     try {
122         AgentClassInfoGatherer agentInfoGatherer = new AgentClassInfoGatherer(
123             itsAgentInfo.itsAgentDirectory, itsAgentInfo.itsAgentFile);
124
125         itsAgentInfo.itsMethods = agentInfoGatherer.getAgentMethods();
126         return true;
127     } catch (FileNotFoundException e1) {
128         InfoDialog info = new InfoDialog(itsWizard,
129             StringResources.LAUNCH_ERROR_TITLE,
130             StringResources.FILE_NOTFOUND);
131         info.setBackground(Color.lightGray);
132         info.show();
133         return false;
134     } catch (IOException e1) {
135         InfoDialog info = new InfoDialog(itsWizard,
136             StringResources.LAUNCH_ERROR_TITLE,
137             StringResources.IOERROR);
138         info.setBackground(Color.lightGray);
139         info.show();
140         return false;
141     } catch (ClassFormatError e1) {

```

```

FindFilePanel.java_1      Tue Nov 12 07:44:47 1996      4

142         InfoDialog info = new InfoDialog(itsWizard,
143             StringResources.LAUNCH_ERROR_TITLE,
144             StringResources.BAD_CLASS_FORMAT);
145         info.setBackground(Color.lightGray);
146         info.show();
147         return false;
148     } catch (NotAgentException e1) {
149         InfoDialog info = new InfoDialog(itsWizard,
150             StringResources.LAUNCH_ERROR_TITLE,
151             StringResources.NOT_AGENT);
152         info.setBackground(Color.lightGray);
153         info.show();
154         return false;
155     } catch (ClassNotFoundException e1) {
156         InfoDialog info = new InfoDialog(itsWizard,
157             StringResources.LAUNCH_ERROR_TITLE,
158             StringResources.BAD_CLASS_FORMAT);
159         info.setBackground(Color.lightGray);
160         info.show();
161         return false;
162     } catch (NoAgentsSkeletonException e1) {
163         InfoDialog info = new InfoDialog(itsWizard,
164             StringResources.LAUNCH_ERROR_TITLE,
165             StringResources.NO_SKELETON);
166         info.setBackground(Color.lightGray);
167         info.show();
168         return false;
169     }
170 }
171
172 /**
173  * Builds the GUI Components for this panel
174  */
175 private void buildPanel() {
176     setLayout(new GridBagLayout());
177
178     Label label1 = new Label(StringResources.FF_TEXT1, Label.LEFT);
179     constrain(this, label1,
180         0, 0, 1, 1,
181         GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0
182         0.0,0.0);
183
184     Label label2 = new Label(StringResources.FF_TEXT2, Label.LEFT);
185     constrain(this, label2,
186         0, 1, 1, 1,
187         GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0
188         0.0,0.0);
189

```

```

FindFilePanel.java_1      Tue Nov 12 07:44:47 1996      5

189
190 Label label3 = new Label(StringResources.FF_TEXT3, Label.LEFT);
191 constrain(this, label3,
192     0, 2, 1, 1,
193     GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
194     0.0, 0.0);
195
196 Label label4 = new Label(StringResources.FF_TEXT4, Label.LEFT);
197 constrain(this, label4,
198     0, 3, 1, 1,
199     GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
200     0.0, 0.0);
201
202 Panel browsePanel = new Panel();
203 constrain(this, browsePanel,
204     0, 4, 1, 1,
205     GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 1.0, 1.0,
206     0.0, 0.0);
207
208 browsePanel.setLayout(new GridBagLayout());
209 Label findFileLabel = new Label(StringResources.FF_FIELD_LABEL, Label.LEFT);
210 constrain(browsePanel, findFileLabel,
211     1, 0, 1, 1,
212     GridBagConstraints.NONE, GridBagConstraints.NORTHWEST, 0.0, 0.0,
213     0.0, 0.0);
214
215 itsFileBrowseField = new TextField(25);
216 constrain(browsePanel, itsFileBrowseField,
217     2, 0, 1, 1,
218     GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 1.0, 1.0,
219     0.0, 0.0);
220
221 itsFileBrowseButton = new Button(StringResources.FF_BROWSE_BUTTON);
222 constrain(browsePanel, itsFileBrowseButton,
223     3, 0, 1, 1,
224     GridBagConstraints.NONE, GridBagConstraints.NORTHWEST, 0.0, 0.0,
225     0.0, 0.0);
226
227 }
228
229 /** Derived from Component.action */
230 public boolean action(Event event, Object what) {
231     if (event.target == itsFileBrowseButton) {
232         doBrowse();
233         return true;
234     }
235     return false;

```

```

FindFilePanel.java_1      Tue Nov 12 07:44:47 1996      6

236     )
237
238     /**
239     * Called in response to selecting the Panel's "Browse... button. Brings up
240     * a Open File Dialog.
241     */
242     private void doBrowse() {
243         FileDialog browse = new FileDialog(Util.getFrame(this), StringResources.BROWSE_DLG_TITLE);
244         browse.setFile("**.class");
245
246         if (itsAgentInfo.itsAgentDirectory != null) {
247             if (itsAgentInfo.itsAgentDirectory.length() != 0) {
248                 browse.setDirectory(itsAgentInfo.itsAgentDirectory);
249             }
250         }
251         browse.show();
252
253         String fullFileName = new String("");
254
255         if (browse.getDirectory() != null) {
256             if (browse.getDirectory().length() != 0) {
257                 fullFileName = browse.getDirectory();
258             }
259         }
260
261         if (browse.getFile() != null) {
262             if (browse.getFile().length() != 0) {
263                 fullFileName = fullFileName + browse.getFile();
264             }
265         }
266
267         if (fullFileName.length() != 0) {
268             itsFileBrowseField.setText(fullFileName);
269         }
270
271         /**
272         * Initializes the Panel for display
273         */
274         public void displayPanel() {
275             String fullFileName = "";
276
277             if (itsAgentInfo.itsAgentDirectory != null) {
278                 if (itsAgentInfo.itsAgentDirectory.length() != 0) {
279                     fullFileName = itsAgentInfo.itsAgentDirectory;
280                 }
281                 if (!fullFileName.endsWith(File.separator)) {
282

```

```
FindFilePanel.java_1      Tue Nov 12 07:44:47 1996      7
283
284
285         fullFileName += File.separator;
286     )
287
288
289     if (itsAgentInfo.itsAgentFile != null) {
290         if (itsAgentInfo.itsAgentFile.length() != 0) {
291             fullFileName += itsAgentInfo.itsAgentFile;
292         }
293     }
294
295     if (fullFileName.length() != 0)
296         itsFileBrowseField.setText(fullFileName);
297 }
298
299
300 }
```

```

1  / * $Header: /com/meitca/hsl/zonesjagents/bootstrap/ItineraryGridDataModel.java 3 11/11/96 5:13p
2  *
3  * Copyright 1996 Horizon Systems Laboratory.
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * A Data Model class for use in conjunction with the Rogue Wave
11 * Grid class
12 *
13 * $Log: /com/meitca/hsl/zonesjagents/bootstrap/ItineraryGridDataModel.java $
14 *
15 * 3 11/11/96 5:13p Billp
16 * Made correction to company name.
17 *
18 * 2 9/04/96 12:36p Walsh
19 * Propagate changes to Destination terminology
20 *
21 * 1 8/29/96 5:21p Walsh
22 * initial version
23 *
24 */
25 package com.meitca.hsl.zonesjagents.bootstrap;
26
27 import com.roguewave.widgets.*;
28 import com.roguewave.widgets.grid.*;
29 import java.util.Vector;
30 import java.util.Enumeration;
31
32 import com.meitca.hsl.zonesjagents.conduit.Destination;
33 import com.meitca.hsl.zonesjagents.conduit.Itinerary;
34
35 /**
36 * Implements a the necessary com.rogue.widgets.grid.* interfaces to
37 * support the display of a Grid object. This class is tied to the
38 * Grid control on the ItineraryPanel of the AgentLaunchWizard. The
39 * grid is used to specify the Itinerary of the Agent to launch
40 * @see Itinerary
41 * @see ItineraryPanel
42 * @see AgentLaunchWizard
43 * @author Thomas Walsh
44 */
45 public class ItineraryGridDataModel extends SelectionGridModel (
46 /** The rows displayed in the grid */
47 Vector
48 itsRows;

```

- 70 -

```

ItineraryGridDataModel.java_1      Tue Nov 12 07:44:47 1996      2

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/** The ItineraryPanel this object is tied to. */
ItineraryPanel itsPanel;

/**
 * Construct a ItineraryGridDataModel
 * @param panel The ItineraryPanel this object is tied to.
 */
public ItineraryGridDataModel(ItineraryPanel panel) {
    itsRows = new Vector();
    itsPanel = panel;
}

/** derived from SelectionGridModel.fetchString */
public String fetchString(int row, int column) {
    try {
        // vectors are zero based...Grids are one based, so we need to
        // subtract one
        Destination aRow = (Destination)itsRows.elementAt(row-1);
        switch (column) {
            case 1:
                return aRow.getDestinationHost();
            default:
                return "";
        }
    } catch (ArrayIndexOutOfBoundsException e) {
        return "";
    }
}

/** derived from SelectionGridModel.fetchInteger */
public int fetchInteger (int row, int column) {
    try {
        // vectors are zero based...Grids are one based, so we need to
        // subtract one
        Destination aRow = (Destination)itsRows.elementAt(row-1);
        switch (column) {
            case 2:
                return aRow.getMethodID() + 1;
            default:
                return 0;
        }
    } catch (ArrayIndexOutOfBoundsException e) {
        return 0;
    }
}

```

```

ItineraryGridDataModel.java_1      Tue Nov 12 07:44:47 1996      3

95      /** derived from SelectionGridModel.update */
96      public boolean update (int row, int column, String value) {
97          Destination      aRow;
98
99          try {
100              // vectors are zero based...Grids are one based, so we need to
101              // subtract one
102              aRow = (Destination)itsRows.elementAt(row-1);
103          } catch (ArrayIndexOutOfBoundsException e){
104              aRow = new Destination();
105              itsRows.insertElementAt(aRow, row-1);
106
107              // a new destination has been added to the Itinerary. Lets add
108              // a new blank row to the Grid so that the user has space to type any
109              // more destinations
110              itsPanel.addRow();
111          }
112
113          switch (column) {
114              case 1:
115                  aRow.setDestinationHost(value);
116                  break;
117              default:
118                  break;
119          }
120          return true;
121      }
122
123      /** derived from SelectionGridModel.update */
124      public boolean update (int row, int column, int value) {
125          Destination      aRow;
126
127          try {
128              // vectors are zero based...Grids are one based, so we need to
129              // subtract one
130              aRow = (Destination)itsRows.elementAt(row-1);
131          } catch (ArrayIndexOutOfBoundsException e){
132              aRow = new Destination();
133              itsRows.insertElementAt(aRow, row-1);
134
135              // a new destination has been added to the Itinerary. Lets add
136              // a new blank row to the Grid so that the user has space to type any
137              // more destinations
138              itsPanel.addRow();
139          }
140
141          switch (column) {

```



```

ItineraryGridDataModel.java_1      Tue Nov 12 07:44:47 1996      4

142         case 2:
143             aRow.setMethodID(value - 1);
144             break;
145         default:
146             break;
147     }
148     return true;
149 }
150
151 /*
152  * Retrieves the Itinerary which has been specified by the user.
153  */
154 public Itinerary getItinerary() {
155     Itinerary itinerary = new Itinerary();
156     Enumeration enum = itsRows.elements();
157     while (enum.hasMoreElements()) {
158         Destination destination = (Destination)enum.nextElement();
159         itinerary.addDestination(destination);
160     }
161     return itinerary;
162 }
163
164 }

```

```

itineraryPanel.java_1      Tue Nov 12 07:44:47 1996      1      11/11/96 5:13p Billp $
1  /* $Header: /com/meitca/hsl/zonesjagents/bootstrap/ItineraryPanel.java 3
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * The ItineraryPanel of the AgentLaunchWizard
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/bootstrap/ItineraryPanel.java $
13 *
14 * 3 11/11/96 5:13p Billp
15 * Made correction to company name.
16 *
17 * 2 9/10/96 11:46a Walsh
18 * remove bogus imports that javac considers illegal
19 *
20 * 1 8/29/96 5:21p Walsh
21 * initial version
22 *
23 */
24 package com.meitca.hsl.zonesjagents.bootstrap;
25 import java.awt.*;
26 import java.io.*;
27 import com.roguewave.widgets.grid.*;
28
29 import com.meitca.hsl.util.Wizard;
30 import com.meitca.hsl.util.WizardPanel;
31
32
33 /**
34 * The third panel of the AgentLaunchWizard. This panel allows the user
35 * to specify the Itinerary of the agent.
36 * @see Itinerary
37 * @see AgentLaunchWizardPanel
38 * @see AgentLaunchWizard
39 * @author Thomas Walsh
40 */
41 public class ItineraryPanel extends AgentLaunchWizardPanel {
42     /** The grid control on the panel */
43     Grid itsGrid;
44
45     /** The data model object used in conjunction with itsGrid */
46     ItineraryGridDataModel itsDataModel;
47

```

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ItineraryPanel.java\_1 Tue Nov 12 07:44:47 1996 2

```

48  /**
49   * Construct the ItineraryPanel and all of its components.
50   * @param wizard The wizard to which this panel belongs (needed by
51   *   super)
52   * @param wiinfozard The AgentLaunchInformation describing this
53   *   agent launch (needed by super)
54   */
55  public ItineraryPanel(Wizard wizard, AgentLaunchInformation info) {
56      super(wizard, info);
57      buildPanel();
58  }
59
60  /**
61   * The Wizard calls this method right before it is going to display
62   * the panel. In this case, the Panel needs to recreate the Grid
63   * so that the ChoiceColumn of the grid contains the names of the
64   * available methods of the currently selected Agent.
65   */
66  public void displayPanel() {
67      remove(itsGrid);
68
69      // Create a new grid model
70      itsDataModel = new ItineraryGridDataModel(this);
71
72      // Create a new Grid in spreadsheet mode.
73      itsGrid = new Grid(Grid.TABLE_MODE, itsDataModel, itsDataModel, itsDataModel);
74      itsGrid.getCellPanel().setVertLineColor(Color.gray);
75      itsGrid.getCellPanel().setHorzLineColor(Color.gray);
76      itsGrid.editable = true;
77
78      // Set the grid column heading panel's attributes //
79      itsGrid.setColumnHeadingPanel(new ColumnHeadingPanel());
80      itsGrid.setColumnHeadingPanel().setBackground(Color.lightGray);
81      itsGrid.setColumnHeadingPanel().setForeground(Color.black);
82      itsGrid.setColumnHeadingPanel().setThreeDStyle(Grid.THREED_RAISED);
83      itsGrid.setColumnHeadingPanel().setHorzLines(true);
84      itsGrid.setColumnHeadingPanel().setTextLines(1);
85
86      // Add a text field column to the grid //
87      TextFieldColumnAttribute coll;
88      coll = new TextFieldColumnAttribute();
89      coll.setTitle(StringResources.DEST_COL_TITLE);
90      coll.setWidth(150);
91      ((TableColumnCollection) itsGrid.getColumnModel()).add(coll);
92
93      ChoiceColumnAttribute choiceColumn = new ChoiceColumnAttribute();
94      choiceColumn.setTitle(StringResources.ACTION_COL_TITLE);
95      choiceColumn.setWidth(150);

```

ItineraryPanel.java\_1 Tue Nov 12 07:44:47 1996 3

```

95 ((TableColumnCollection) itsGrid.getColumnModel()).add(choiceColumn);
96
97
98 // Set the grid to have 1 row. //
99 (itsGrid.getRowCollection()).setRows(1);
100
101 constrain(this, itsGrid,
102             0, 6, 1, 1,
103             GridBagConstraints.BOTH, GridBagConstraints.NORTHWEST, 1.0, 1.0,
104             0.0, 0.0);
105
106
107 choiceColumn.addItem("");
108 for(int i=0; i<itsAgentInfo.itsMethods.length; i++) {
109     choiceColumn.addItem(itsAgentInfo.itsMethods[i]);
110 }
111
112 invalidate();
113 validate();
114
115
116 /**
117  * Verify that the information entered into the panel is valid. Called
118  * after the "Next >" button is pressed.
119  * There is no actual verification necessary. This method simply
120  * retrieves the itinerary from the data model and stuffs it into
121  * the AgentLaunchInfo.
122  * @returns true if the panel contains valid info, false if not
123  */
124 public boolean validatePanel() {
125     itsAgentInfo.itsitinerary = itsDataModel.getItinerary();
126     return true;
127 }
128
129 /**
130  * Builds the GUI Components for this panel
131  */
132 private void buildPanel() {
133     setLayout(new GridBagLayout());
134
135     Label label1 = new Label(StringResources.ITIN_TEXT1, Label.LEFT);
136     constrain(this, label1,
137             0, 0, 1, 1,
138             GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.
139             0.0, 0.0);
140
141     Label label2 = new Label(StringResources.ITIN_TEXT2, Label.LEFT);

```

- 76 -

```

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ItineraryPanel.java_1      Tue Nov 12 07:44:47 1996      4

    constrain(this, label2,
        0, 1, 1, 1,
        GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
        0.0, 0.0);

    Label label3 = new Label(StringResources.ITIN_TEXT3, Label.LEFT);
    constrain(this, label3,
        0, 2, 1, 1,
        GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
        0.0, 0.0);

    Label label4 = new Label(StringResources.ITIN_TEXT4, Label.LEFT);
    constrain(this, label4,
        0, 3, 1, 1,
        GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
        0.0, 0.0);

    Label label5 = new Label(StringResources.ITIN_TEXT5, Label.LEFT);
    constrain(this, label5,
        0, 4, 1, 1,
        GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
        0.0, 0.0);

    Label label6 = new Label(StringResources.ITIN_TEXT6, Label.LEFT);
    constrain(this, label6,
        0, 5, 1, 1,
        GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
        0.0, 0.0);

    // Crate a new grid model
    itsDataModel = new ItineraryGridDataModel(this);
    // Crate a new Grid in spreadsheet mode.
    itsGrid = new Grid(Grid.TABLE_MODE, itsDataModel, itsDataModel, itsDataModel);
    itsGrid.getCellPanel().setVertLineColor(Color.gray);
    itsGrid.getCellPanel().setHorzLineColor(Color.gray);
    itsGrid.editable = true;

    // Set the grid column heading panel's attributes //
    itsGrid.setColumnHeadingPanel(new ColumnHeadingPanel());
    itsGrid.setColumnHeadingPanel().setBackground(Color.lightGray);
    itsGrid.setColumnHeadingPanel().setForeground(Color.black);
    itsGrid.setColumnHeadingPanel().setThreeDStyle(Grid.THREED_RAISED);
    itsGrid.setColumnHeadingPanel().setHorzLines(true);
    itsGrid.setColumnHeadingPanel().setTextLines(1);

```

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```

189 ItineraryPanel.java_1      Tue Nov 12 07:44:47 1996      5
190 // Add a text field column to the grid //
191 TextFieldColumnAttribute coll;
192 coll = new TextFieldColumnAttribute();
193 coll.setTitle(StringResources.DEST_COL_TITLE);
194 coll.setWidth(150);
195 ((TableColumnCollection) itsGrid.getColumnModel()).add(coll);
196
197 ChoiceColumnAttribute choiceColumn = new ChoiceColumnAttribute();
198 choiceColumn.setTitle(StringResources.ACTION_COL_TITLE);
199 choiceColumn.setWidth(150);
200 ((TableColumnCollection) itsGrid.getColumnModel()).add(choiceColumn);
201
202 // Set the grid to have 1 row. //
203 (itsGrid.getRowCollection()).setRows(1);
204
205 constrain(this, itsGrid,
206             0, 6, 1, 1,
207             GridBagConstraints.BOTH, GridBagConstraints.NORTHWEST, 1.0, 1.0,
208             0.0, 0.0);
209
210
211
212
213 /**
214  * called by the ItineraryGridDataModel to signify that a new row should be
215  * added to the Grid
216  */
217 protected void addRow() {
218     itsGrid.getRowCollection().setRows(itsGrid.getRowCollection().count()+1);
219 }
220

```

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```

189 ItineraryPanel.java_1      Tue Nov 12 07:44:47 1996      5
190 // Add a text field column to the grid //
191 TextFieldColumnAttribute coll;
192 coll = new TextFieldColumnAttribute();
193 coll.setTitle(StringResources.DEST_COL_TITLE);
194 coll.setWidth(150);
195 ((TableColumnCollection) itsGrid.getColumnModel()).add(coll);
196
197 ChoiceColumnAttribute choiceColumn = new ChoiceColumnAttribute();
198 choiceColumn.setTitle(StringResources.ACTION_COL_TITLE);
199 choiceColumn.setWidth(150);
200 ((TableColumnCollection) itsGrid.getColumnModel()).add(choiceColumn);
201
202 // Set the grid to have 1 row. //
203 (itsGrid.getRowCollection()).setRows(1);
204
205 constrain(this, itsGrid,
206            0, 6, 1, 1,
207            GridBagConstraints.BOTH, GridBagConstraints.NORTHWEST, 1.0, 1.0,
208            0.0, 0.0);
209
210
211
212
213 /**
214  * called by the ItineraryGridDataModel to signify that a new row should be
215  * added to the Grid
216  */
217 protected void addRow() {
218     itsGrid.getRowCollection().setRows(itsGrid.getRowCollection().count()+1);
219 }
220
221

```

```

NoAgentSkeletonException.java_1      Tue Nov 12 07:44:48 1996      1      11/11/96 5:13p Billp $
1  /*      $Header: /ccm/meitca/hsl/zonesjagents/bootstrap/NoAgentSkeletonException.java 2
2  *      Copyright 1996 Horizon Systems Laboratory,
3  *      Mitsubishi Electric Information Technology Center America.
4  *      All rights reserved.
5  *
6  *      CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
7  *
8  *      DESCRIPTION
9  *      Exception indicating that Agent invocation Skeleton is missing.
10 *
11 *      $Log: /ccm/meitca/hsl/zonesjagents/bootstrap/NoAgentSkeletonException.java $
12 *
13 *      2      11/11/96 5:13p Billp
14 *      Made correction to company name.
15 *
16 *      1      8/29/96 5:21p Walsh
17 *      initial version
18 *
19 *
20 */
21 package com.meitca.hsl.zonesjagents.bootstrap;
22
23 /**
24 *      Exception indicates that the system could not locate the Agent
25 *      method invocation skeleton. This skeleton is used by the conduit
26 *      server to invoke the proper method on the Agent when it arrives
27 *      at a destination. The skeleton is generated by the Agent Skeleton
28 *      Generator.
29 *      @see      Agent
30 *      @see      AgentSkeleton
31 *      @author    Thomas Walsh
32 */
33 public class NoAgentSkeletonException extends Exception {
34     public NoAgentSkeletonException() {
35         super();
36     }
37
38     public NoAgentSkeletonException(String s) {
39         super(s);
40     }
41 }

```



```

NotAgentException.java_1      Tue Nov 12 07:44:48 1996      1      11/11/96 5:13p Billp $
1  /*      $Header: /com/meitca/hsl/zonesjagents/bootstrap/NotAgentException.java 3
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Exception indicating that a .class File does not contain an Agent.
11 *
12 *      $Log: /com/meitca/hsl/zonesjagents/bootstrap/NotAgentException.java $
13 *
14 * 3      11/11/96 5:13p Billp
15 * Made correction to company name.
16 *
17 * 2      9/30/96 6:35p Walsh
18 * fix up javadoc comments
19 *
20 * 1      8/29/96 5:21p Walsh
21 * intial version
22 *
23 */
24 package com.meitca.hsl.zonesjagents.bootstrap;
25
26 /**
27 * Exception indicates the class File specified did not contain
28 * a Java class derived from Agent.
29 * @see      Agent
30 * @author      Thomas Walsh
31 */
32 public class NotAgentException extends Exception {
33     public NotAgentException() {
34         super();
35     }
36
37     public NotAgentException(String s) {
38         super(s);
39     }
40 }

```

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```

RelatedFilesPanel.java_1      Tue Nov 12 07:44:48 1996      1      11/11/96 5:13p Billp $
1  /* $Header: /com/meitca/hsl/zonesjagents/bootstrap/RelatedFilesPanel.java 3
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * The RelatedFilesPanel of the AgentLaunchWizard
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/bootstrap/RelatedFilesPanel.java $
13 * 3 11/11/96 5:13p Billp
14 * Made correction to company name.
15 *
16 * 2 9/10/96 11:46a Walsh
17 * remove bogus imports that javac considers illegal
18 *
19 * 1 8/29/96 5:21p Walsh
20 * initial version
21 *
22 *
23 */
24 package com.meitca.hsl.zonesjagents.bootstrap;
25
26 import java.awt.*;
27 import java.io.*;
28
29 import com.meitca.hsl.util.Wizard;
30 import com.meitca.hsl.util.WizardPanel;
31
32
33 /**
34 * The second panel of the AgentLaunchWizard. This panel allows the user
35 * to specify the filenames of classes that should be sent with the agent.
36 *
37 * @see Agent
38 * @see AgentLaunchWizardPanel
39 * @see AgentLaunchWizard
40 * @author Thomas Walsh
41 */
42 public class RelatedFilesPanel extends AgentLaunchWizardPanel {
43     /** The list control form which the user selects files */
44     List itsRelatedClassesList;
45
46     /**
47      * Construct the FindFilePanel and all of its components.

```

```

RelatedFilesPanel.java_1      Tue Nov 12 07:44:48 1996      2

48      * @param      wizard The wizard to which this panel belongs (needed by
49      *              super)
50      * @param      winfozard The AgentLaunchInformation describing this
51      *              agent launch (needed by super)
52      */
53      public RelatedFilesPanel(Wizard wizard, AgentLaunchInformation info) {
54          super(wizard, info);
55          buildPanel();
56      }
57
58      /**
59      * The Wizard calls this method right before it is going to display
60      * the panel. In this case, the Panel needs to fill the List
61      * with the names of all the .class files in the same directory as
62      * the Agent.
63      */
64      public void displayPanel() {
65          File agentDir = new File(itsAgentInfo.itsAgentDirectory);
66          String[] files = agentDir.list(new ClassFileFilter());
67
68          itsRelatedClassesList.clear();
69          for (int i=0; i<files.length; i++) {
70              if (!files[i].equals(itsAgentInfo.itsAgentFile))
71                  itsRelatedClassesList.addItem(files[i]);
72          }
73      }
74
75
76      /**
77      * Verify that the information entered into the panel is valid. Called
78      * after the "Next >" button is pressed.
79      * There is no actual verification necessary. This method simply
80      * retrieves the list of classes and stuffs them into the
81      * AgentLaunchInfo
82      * @returns      true if the panel contains valid info, false if not
83      */
84      public boolean validatePanel() {
85          itsAgentInfo.itsRelatedClasses = itsRelatedClassesList.getSelectedItems();
86          return true;
87      }
88
89      /**
90      * Builds the GUI Components for this panel
91      */
92      private void buildPanel() {
93          setLayout(new GridBagLayout());
94

```

```

RelatedFilesPanel.java_1      Tue Nov 12 07:44:48 1996      3

95     Label label1 = new Label(StringResources.RF_TEXT1, Label.LEFT);
96     constrain(this, label1,
97         0, 0, 1, 1,
98         GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
99         0.0, 0.0);
100
101     Label label2 = new Label(StringResources.RF_TEXT2, Label.LEFT);
102     constrain(this, label2,
103         0, 1, 1, 1,
104         GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
105         0.0, 0.0);
106
107
108     Label label3 = new Label(StringResources.RF_TEXT3, Label.LEFT);
109     constrain(this, label3,
110         0, 2, 1, 1,
111         GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
112         0.0, 0.0);
113
114
115     Label label4 = new Label(StringResources.RF_TEXT4, Label.LEFT);
116     constrain(this, label4,
117         0, 3, 1, 1,
118         GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
119         0.0, 0.0);
120
121     Label label5 = new Label(StringResources.RF_TEXT5, Label.LEFT);
122     constrain(this, label5,
123         0, 4, 1, 1,
124         GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
125         0.0, 0.0);
126
127     Label label6 = new Label(StringResources.RF_TEXT6, Label.LEFT);
128     constrain(this, label6,
129         0, 5, 1, 1,
130         GridBagConstraints.HORIZONTAL, GridBagConstraints.NORTHWEST, 0.0, 0.0,
131         0.0, 0.0);
132
133     itsRelatedClassesList = new List(7, true);
134     constrain(this, itsRelatedClassesList,
135         0, 6, 1, GridBagConstraints.REMAINDER,
136         GridBagConstraints.BOTH, GridBagConstraints.NORTHWEST, 1.0, 1.0,
137         0.0, 0.0);
138
139 }
140
141 /**

```

```
RelatedFilesPanel.java_1      Tue Nov 12 07:44:48 1996      4

142 * A FilenameFilter object than scans for file ending in .class
143 */
144 class ClassFileFilter implements FilenameFilter {
145     public boolean accept(File dir, String name) {
146         return (name.endsWith(".class"));
147     }
148 }
```

```

StringResources.java_1      Tue Nov 12 07:44:48 1996      1      11/11/96 5:13p Billp $

1  /* $Header: /com/meitca/hsl/zonesjagents/bootstrap/StringResources.java 7
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * The String Resources for the bootstrap package
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/bootstrap/StringResources.java $
13 *
14 * 7 11/11/96 5:13p Billp
15 * Made correction to company name.
16 *
17 * 6 10/07/96 4:44p Walsh
18 * Save name & location of last agent launched. Restart Wizard pointing
19 * at same agent.
20 *
21 * 5 9/15/96 5:11p Walsh
22 * Fix spelling mistakes
23 *
24 * 4 9/09/96 5:59p Walsh
25 * Make constants final
26 *
27 * 3 9/05/96 6:37p Walsh
28 * Add some string constants associated with the command line launch
29 * utility.
30 *
31 * 2 9/04/96 12:36p Walsh
32 * Add launch error message
33 *
34 * 1 8/29/96 5:21p Walsh
35 * initial version
36 *
37 */
38 package com.meitca.hsl.zonesjagents.bootstrap;
39
40 class StringResources {
41
42     // AgentLaunchWizard.java
43     public static String WIZARD_TITLE = "Agent Launch Wizard";
44     public static String WIZARD_APPNAME = "AgentLaunchWizard";
45     public static String PROP_DESC = "Properties file for Zones Agent Launch Wizard";
46
47     // FindFilePanel.java

```

```

StringResources.java_1      Tue Nov 12 07:44:48 1996      2

48 public static final String LAUNCH_ERROR_TITLE = "Launch Error";
49 public static final String NO_FILENAME = "You must specify the filename of the .class file containing the a
nt.";
50 public static final String ENDSWITH_CLASS = "You must specify a file ending with .class.";
51 public static final String FF_TEXT1 = "This wizard will assist you in launching Agents";
52 public static final String FF_TEXT2 = "Please select the .class file containing the ";
53 public static final String FF_TEXT3 = "agent you would like to launch.";
54 public static final String FF_TEXT4 = " ";
55 public static final String FF_FIELD_LABEL = "Class File: ";
56 public static final String FF_BROWSE_BUTTON = "Browse...";
57 public static final String BROWSE_DLG_TITLE = "Open Agent Class File";
58
59 //ItineraryPanel.java
60 public static final String DEST_COL_TITLE = "Destination";
61 public static final String ACTION_COL_TITLE = "Action";
62 public static final String ITIN_TEXT1 = "An agent's itinerary specifies where an agent travels to and";
63 public static final String ITIN_TEXT2 = "what operations the agent performs as it travels. Please ";
64 public static final String ITIN_TEXT3 = "specify the itinerary below. You should enter the host-";
65 public static final String ITIN_TEXT4 = "names of the machines you would like your agent to travel ";
66 public static final String ITIN_TEXT5 = "to as well as the methods you would like called at each stop.";
67 public static final String ITIN_TEXT6 = " ";
68
69 // RelatedFilesPanel.java
70 public static final String RF_TEXT1 = "You may specify a list of classes which should be sent with";
71 public static final String RF_TEXT2 = "the Agent. These should be classes which the Agent is likely";
72 public static final String RF_TEXT3 = "to use while it is travelling. ";
73 public static final String RF_TEXT4 = " ";
74 public static final String RF_TEXT5 = "Please select any classes you would like sent with the agent.";
75 public static final String RF_TEXT6 = " ";
76
77 // Bootstrap.java
78 public static final String USAGE = "Usage: bootstrap [-d hostname,method] [-f relatedfile.class]\n\t[-h) a
tfile.class";
79 public static final String ILLEGAL_OPTN = "bootstrap: illegal option -- ";
80 public static final String SYNTAX_ERROR = "bootstrap: syntax error -- ";
81 public static final String ILLEGAL_AGENT = "bootstrap: illegal agent file -- ";
82 public static final String NO_AGENT = "bootstrap: No agent specified";
83 public static final String AGENT_HELP = "\tThe agent files must be valid Java class file\n\tand must end wi
.class";
84 public static final String ILLEGAL_RELFILE = "bootstrap: Illegal related filename -- ";
85 public static final String RELFILE_HELP = "\tThe related files specified by the -f option\n\tmust be valid
va class files and must end\n\twith .class";
86 public static final String ILLEGAL_DEST = "bootstrap: Illegal destination specification -- ";
87 public static final String ILLEGAL_METHOD = "bootstrap: Illegal method name -- ";
88 public static final String NO_DEST = "bootstrap: You must specify at least destination";
89
90 // shared strings

```

```
StringResources.java_1      Tue Nov 12 07:44:48 1996      3

91 public static final String FILE_NOTFOUND = "Could not find the file specified.";
92 public static final String IOERROR = "An error occurred while trying to access the file specified.
93 public static final String BAD_CLASS_FORMAT = "The file specified did not contain a valid Java cla
94 public static final String NOT_AGENT = "The file specified did not contain a Java Agent.";
95 public static final String NO_SKELETON = "Could not locate the Agent's skeleton.";
96 public static final String LAUNCH_ERROR = "An error occurred while attempting to launch the Agent"
97
98 )
```



```

AgentPackage.java_1      Tue Nov 12 07:45:01 1996      1
1 /* $Header: /com/meitca/hsl/zonesjagents/conduit/AgentPackage.java 18 11/11/96 5:15p Billp $
2 *
3 * Copyright 1996 Horizon Systems Laboratory,
4 * Mitsubishi Electric Information Technology Center America.
5 * All rights reserved.
6 *
7 * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8 *
9 * DESCRIPTION
10 * Agent transportation package object
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/conduit/AgentPackage.java $
13 *
14 * 18 11/11/96 5:15p Billp
15 * Made correction to company name.
16 *
17 * 17 10/28/96 6:31p Walsh
18 * Add more debugging info
19 *
20 * 16 10/24/96 5:15p Walsh
21 * add some debugging information related to memory usage.
22 *
23 * 15 10/23/96 2:22p Walsh
24 * add more Debug.println's
25 *
26 * 14 10/11/96 9:26a Walsh
27 * fix compiler bug
28 *
29 * 13 10/10/96 6:02p Walsh
30 * Add persistence support
31 *
32 * 12 9/30/96 7:06p Walsh
33 * clean up javadoc comments
34 *
35 * 11 9/29/96 4:08p Walsh
36 * Allow Destination methods to be specified by name
37 * Give Agent access to AgentPackage information
38 *
39 * 10 9/11/96 12:24p Walsh
40 * remove unneeded import of CollaboratorAgent
41 *
42 * 9 9/09/96 4:59p Walsh
43 * Call Agent prepareForTransport, completedTransport methods
44 *
45 * 8 8/23/96 3:58p Walsh
46 * Add support for ad-hoc method invocation
47 *

```

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AgentPackage.java\_1 Tue Nov 12 07:45:01 1996 2

```

48 * 7 8/22/96 5:45p Walsh
49 * Move the custom marshalling of the agent into the AgentPackage class
50 *
51 * 6 8/19/96 5:26p Walsh
52 * Add support for remote class loading
53 *
54 * 5 8/09/96 4:38p Walsh
55 * Setting up file headers
56 */
57
58 package com.meitca.hsl.zonesjagents.conduit;
59
60 import java.io.*;
61 import java.net.*;
62 import java.rmi.server.MarshalException;
63
64
65 import com.meitca.hsl.zonesjagents.shared.Agent;
66 import com.meitca.hsl.util.*;
67
68 /**
69  * An AgentPackage contains an Agent, its MobileCodebase and
70  * its Itinerary. The AgentPackage is passes between ConduitServers
71  * when the Agent travels.
72  * @see ConduitServerImpl
73  * @author Thomas Walsh
74  */
75
76 public class AgentPackage {
77     Agent
78     MobileCodebase
79     Itinerary
80     String
81     int
82
83
84
85
86
87
88
89
90
91
92
93
94
    /**
    * Constructs an AgentPackage
    * @param agent The Agent
    * @param code The Agent's mobile codebase
    * @param itinerary The Agents itinerary
    * @param homeCodebaseURL The URL of the Agent's codebase
    */
    public AgentPackage(Agent agent, MobileCodebase codebase,
        Itinerary itinerary, String homeCodebaseURL) {
        Debug.println("conduit.memory", 3, "AgentPackage " + this + " created");
    }

```

```

AgentPackage.java_1      Tue Nov 12 07:45:01 1996      3

    95     itsAgent = agent;
    96     itsMobileCodebase = codebase;
    97     itsItinerary = itinerary;
    98     itsHomeCodebaseURL = homeCodebaseURL;
    99     itsOID = 0;
   100 }
   101
   102 protected void finalize() throws Throwable {
   103     Debug.println("conduit.memory", 3, "AgentPackage " + this + " finalized");
   104     super.finalize();
   105 }
   106
   107 /** Retrieves the Agent from the package */
   108 public Agent getAgent() {
   109     return itsAgent;
   110 }
   111
   112 /** Retrieves the Agent's Mobile Codebase from the package */
   113 public MobileCodebase getMobileCodebase() {
   114     return itsMobileCodebase;
   115 }
   116
   117 /** Retrieves the Agent's itinerary from the package */
   118 public Itinerary getItinerary() {
   119     return itsItinerary;
   120 }
   121
   122 /** Retrieves the Agent's codebase URL from the package */
   123 public String getHomeCodebaseURL() {
   124     return itsHomeCodebaseURL;
   125 }
   126
   127 /**
   128  * Prepares the Agent package for network transmission. This method
   129  * performs the conversion of the Agent to a network transmission
   130  * format. This method also calls the Agent's prepareForTransport
   131  * method.
   132  */
   133 public void prepareForTransport() {
   134     Debug.println("conduit", 2, "AgentPackage.prepareForTransport called");
   135
   136     // give the agent a chance to do any work in preparation
   137     // for transport
   138     itsAgent.prepareForTransport();
   139 }
   140
   141 /**

```

AgentPackage.java\_1 Tue Nov 12 07:45:01 1996 4

```

142 * Restores the Agent package for network transmission from its
143 * network transmission format. This method also calls the Agent's
144 * completedTransport method.
145 */
146 public void restoreFromTransportForm() {
147     Debug.println("conduit", 2, "AgentPackage.restoreFromTransportForm called");
148
149     // give the agent a chance to do any work in preparation
150     // for arrival at destination
151     itsAgent.completedTransport();
152 }
153
154 private void readObject(ObjectInputStream stream)
155     throws IOException, ClassNotFoundException {
156     Debug.println("conduit", 2, "AgentPackage.readObject called");
157
158     itsMobileCodebase = (MobileCodebase)stream.readObject();
159     Debug.println("conduit", 4, "read MobileCodebase: " + itsMobileCodebase);
160
161     itsItinerary = (Itinerary)stream.readObject();
162     Debug.println("conduit", 4, "read Itinerary: " + itsItinerary);
163
164     itsHomeCodebaseURL = (String)stream.readObject();
165     Debug.println("conduit", 4, "read Codebase URL: " + itsHomeCodebaseURL);
166
167     // do the special deserialization of the Agent using the
168     // ConduitObjectInputStream class
169     ConduitServerClassLoader classLoader = new ConduitServerClassLoader(itsMobileCodebase, itsHomeCodebaseURL);
170     eURL);
171
172     // unmarshal the agent, build the AgentPackage and then pass it along to receiveAgent
173     byte[]
174     ByteArrayInputSteam    byteInStream = new ByteArrayInputSteam(serializedAgent);
175     ConduitObjectInputSteam    marshalInput = new ConduitObjectInputSteam(byteInStream, classLoad
176 );
177
178     Debug.println("conduit", 4, "about to read Agent");
179     itsAgent = (Agent)marshalInput.readObject();
180     Debug.println("conduit", 4, "read Agent: " + itsAgent);
181
182     // Restore the Agents reference to its Package will be
183     // restored when the agent arrives at the Destination
184     itsAgent.setPackage(this);
185
186     private void writeObject(ObjectOutputStream stream)
187         throws IOException {

```

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AgentPackage.java\_1

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```

187 Debug.println("conduit", 2, "AgentPackage.writeObject called");
188
189 stream.writeObject(itsMobileCodebase);
190 stream.writeObject(itsItinerary);
191 stream.writeObject(itsHomeCodebaseURL);
192
193 // do the special deserialization of the Agent using the
194 // ConduitObjectOutputStream class
195
196 // null out the Agents pointer to the AgentPackage. We have to
197 // do this because Java object persistence does not support
198 // isomorphic persistence. Since the AgentPackage has a
199 // reference to the Agent and the Agent has a reference
200 // to the AgentPackage we have a circular reference.
201 // Without isomorphic persistence, this circular reference
202 // would cause the object serialization code to go into an
203 // infinite loop. The reference to itsPackage will be
204 // restored when the agent arrives at the Destination
205 // itsAgent.setPackage(null);
206
207 ByteArrayOutputStream byteOutputStream = new ByteArrayOutputStream();
208 ConduitObjectOutputStream marshalOutput = new ConduitObjectOutputStream(byteOutputStream);
209
210 // use object serialization to stream the agent to a byte array
211 marshalOutput.writeObject(itsAgent);
212 byte[] serializedAgent = byteOutputStream.toByteArray();
213
214 // finally write the serialized agent to the original output stream
215 stream.writeObject(serializedAgent);
216
217 )
218
219 /** Retrieves the AgentSkeleton object corresponding to the Agent. */
220 AgentSkeleton getAgentSkeleton() throws ClassNotFoundException, InstantiationException, IllegalAccessException {
221 {
222     String agentClassName = itsAgent.getClass().getName();
223     String skelClassName = agentClassName + "_Skel";
224     ConduitServerClassLoader classLoader = (ConduitServerClassLoader)itsAgent.getClass().getClassLoader();
225
226     if (classLoader != null)
227         return (AgentSkeleton)(classLoader.loadClass(skelClassName).newInstance());
228     else
229         return (AgentSkeleton)(Class.forName(skelClassName).newInstance());
230
231 void setOID(int oid) {
232     itsOID = oid;
233 }

```

6

AgentPackage.java\_1 Tue Nov 12 07:45:01 1996

```
232         int getOID() {
233             return itsOID;
234         }
235     }
236 }
```

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```

AgentsSkeleton.java_1      Tue Nov 12 07:45:01 1996      1      11/11/96 5:15p Billp $
1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/AgentSkeleton.java 3
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Agent method invocation skeleton interface
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/conduit/AgentSkeleton.java $
13  *
14  * 3 11/11/96 5:15p Billp
15  * Made correction to company name.
16  *
17  * 2 8/29/96 5:15p Walsh
18  * Add getMethods method
19  *
20  * 1 8/23/96 3:50p Walsh
21  * Initial versions
22  */
23 package com.meitca.hsl.zonesjagents.conduit;
24
25 import com.meitca.hsl.zonesjagents.shared.Agent;
26
27 /**
28  * An interface representing an Agent ad-hoc method invocation skeleton.
29  * The skeleton allows the ConduitServer to make a call to any method within
30  * the Agent. At runtime, the ConduitServer looks at the Agent's Itinerary
31  * and determines what method should be called at the current location. The
32  * skeleton allows the Conduit Server to call the method.
33  * @see Agent
34  * @see ConduitServer
35  * @author Thomas Walsh
36  */
37 public interface AgentSkeleton {
38
39     /**
40     * Invokes a method on an agent
41     * @param agent The agent whose method to invoke.
42     * @param i The method ID number of the method to invoke.
43     */
44     public void invoke(Agent agent, int i) throws IllegalAccessException;
45
46     /**
47     * Retrieves a list of the agent methods which can be invoked by

```

```
AgentSkeleton.java_1      Tue Nov 12 07:45:01 1996      2
48      * the skeleton.
49      */
50      public String[] getMethods();
51
52  )
```



```

AgentThread.java_1      Tue Nov 12 07:45:02 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/AgentThread.java 4 11/11/96 5:15p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * provides the thread in which an Agent will execute.
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/conduit/AgentThread.java $
13  *
14  * 4 11/11/96 5:15p Billp
15  * Made correction to company name.
16  *
17  * 3 10/29/96 5:28p Walsh
18  * Use ErrorLog class to report errors
19  *
20  * 2 10/28/96 6:31p Walsh
21  * Add more debugging info
22  *
23  * 1 10/25/96 5:02p Walsh
24  * Make AgentThread public
25  *
26  */
27 package com.meitca.hsl.zonesjagents.conduit;
28
29 import java.util.*;
30
31 import com.meitca.hsl.zonesjagents.shared.*;
32 import com.meitca.hsl.util.*;
33
34 /**
35  * A subclass of Thread. AgentThread provides the thread in which an Agent will
36  * execute.
37  * @see Agent
38  * @see ConduitServer
39  * @author Thomas Walsh
40  */
41 public class AgentThread extends Thread {
42     AgentPackage itsPackage;
43
44     /**
45      * Constructs an AgentThread
46      * @param agentPackage The package containing the agent, its code and
47      * its itinerary.

```

AgentThread.java\_1 Tue Nov 12 07:45:02 1996 2

```

48 */
49 public AgentThread(AgentPackage agentPackage) {
50     Debug.println("conduit.memory", 3, "AgentThread " + this + " created");
51     itsPackage = agentPackage;
52     this.start();
53 }
54
55 protected void finalize() throws Throwable {
56     Debug.println("conduit.memory", 3, "AgentThread " + this + " finalized");
57     super.finalize();
58 }
59
60 /**
61  * Retrieves a reference to the Agent which is executing within this
62  * AgentThread
63  */
64 public Agent getAgent() {
65     return itsPackage.getAgent();
66 }
67
68 /**
69  * Retrieves a reference to the AgentPackage contained within this
70  * AgentThread
71  */
72 public AgentPackage getAgentPackage() {
73     return itsPackage;
74 }
75
76 /**
77  * Begins the Agent's execution
78 */
79 public void run() {
80     try {
81         ConduitServerImpl.getPersistenceStore().addStore(itsPackage);
82         AgentSkeleton skel = itsPackage.getAgentSkeleton();
83         Destination current = itsPackage.getItinerary().getCurrentLocation();
84
85         if (current.getMethodID() == Destination.UNKNOWN_METHOD_ID) {
86             current.convertNameToId(skel);
87         }
88
89         skel.invoke(itsPackage.getAgent(),
90             current.getMethodID());
91         itsPackage.getItinerary().getCurrentLocation().setCompleted();
92         ConduitServerImpl.getPersistenceStore().updateStore(itsPackage);
93     } catch (Exception error) {
94         ErrorLog.println("conduit.AgentThread",

```

```

AgentThread.java_1      Tue Nov 12 07:45:02 1996      3
95      ErrorLog.SEVERITY_ERROR,
96      "An error occurred while executing Agent:",
97      error);
98      )
99
100     ConduitServerImpl.decrementAgentCounters();
101
102     try {
103         // pass the agent along.
104         ConduitServerImpl.sendPackage(itsPackage);
105     } catch (NoSuchElementException done) {
106         Debug.println("conduit", 1, "AgentThread.run: No more destinations for Agent " +
107             itsPackage.getAgent().get
tID());
108     } catch (Exception error) {
109         ErrorLog.println("conduit.AgentThread",
110             ErrorLog.SEVERITY_ERROR,
111             "An error occurred while transporting Agent:",
112             error);
113     }
114
115     // remove the agent from the persistence store
116     ConduitServerImpl.getPersistenceStore().removeFromStore(itsPackage);
117 }
118 }

```

```

ConduitObjectInputStream.java_1      Tue Nov 12 07:45:02 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/ConduitObjectInputStream.java 9 11/11/96 5:15p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Specialized ObjectInputStream used for agent deserialization
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/conduit/ConduitObjectInputStream.java $
13  *
14  * 9 11/11/96 5:15p Billp
15  * Made correction to company name.
16  *
17  * 8 11/01/96 5:32p Walsh
18  * Modify debugging levels of debug output
19  *
20  * 7 10/21/96 4:26p Walsh
21  * Add debug logging
22  *
23  * 6 9/30/96 7:06p Walsh
24  * clean up javadoc comments
25  *
26  * 5 9/11/96 6:40p Walsh
27  * fix compiler error
28  *
29  * 4 9/11/96 6:33p Walsh
30  * derive from MarshalStream
31  *
32  * 3 8/22/96 2:19p Walsh
33  * Clean up code a little
34  *
35  * 2 8/13/96 5:09p Walsh
36  * Added comments & documentation. resolveClass now uses
37  * ConduitServerClassLoader
38  *
39  * 1 8/12/96 7:17p Walsh
40  * Initial versions
41  */
42 package com.meitca.hsl.zonesjagents.conduit;
43
44 import java.io.InputStream;
45 import java.io.IOException;
46 import java.io.StreamCorruptedException;
47 import java.lang.ClassNotFoundException;

```

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```

ConduitObjectOutputStream.java_1      Tue Nov 12 07:45:02 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/ConduitObjectOutputStream.java 7 11/11/96 5:15p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Specialized MarshalInputStream used for agent deserialization
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/conduit/ConduitObjectOutputStream.java $
13  *
14  * 7 11/11/96 5:15p Billp
15  * Made correction to company name.
16  *
17  * 6 11/01/96 5:32p Walsh
18  * Modify debugging levels of debug output
19  *
20  * 5 10/21/96 4:26p Walsh
21  * Add debug logging
22  *
23  * 4 9/30/96 7:06p Walsh
24  * clean up javadoc comments
25  *
26  * 3 9/11/96 6:33p Walsh
27  * derive from Marshal*Stream
28  *
29  * 2 8/22/96 2:19p Walsh
30  * Clean up code a little
31  *
32  * 1 8/12/96 7:17p Walsh
33  * Initial versions
34  */
35 package com.meitca.hsl.zonesjagents.conduit;
36
37 import java.io.OutputStream;
38 import java.io.IOException;
39 import java.io.StreamCorruptedException;
40 import java.lang.ClassNotFoundException;
41 import java.rmi.server.MarshalOutputStream;
42
43 import com.meitca.hsl.util.*;
44
45 public class ConduitObjectOutputStream
46     extends MarshalOutputStream {
47

```

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```
ConduitObjectInputStream.java_1      Tue Nov 12 07:45:02 1996      3
95      Debug.println("conduit.classload", 3, "ConduitObjectInputStream.resolveClass called for " + classr..
);
96
97      return itsClassLoader.loadClass(classname);
98
99  )
```

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ConduitObjectInputStream.java\_1 Tue Nov 12 07:45:02 1996 2

```

48 import java.rmi.server.MarshalInputStream;
49 import java.net.MalformedURLException;
50 import java.net.URL;
51 import java.rmi.server.StubClassLoader;
52
53 import com.meitca.hsl.util.*;
54
55 /**
56  * A subclass of ObjectInputStream which is used to handle deserialization
57  * of Agent objects. ConduitObjectInputStream overrides the
58  * ObjectInputStream.resolveClass method. As the deserialization process
59  * encounters object contained within the agent, resolveClass is called for
60  * each unique class. resolveClass makes use of a ConduitServerClassLoader
61  * object to search the agents MobileCodebase for class bytecodes.
62  * @see Agent
63  * @see ConduitServerClassLoader
64  * @see ObjectInputStream
65  * @see MobileCodebase
66  * @author Thomas Walsh
67  */
68 class ConduitObjectInputStream
69     extends MarshalInputStream {
70
71     /** Class loader object used for deserializing an agent. */
72     ConduitServerClassLoader itsClassLoader;
73
74     /**
75      * Constructs a ConduitObjectInputStream
76      * is The InputStream containing the Agent object.
77      * @param classLoader A ConduitServerClassLoader capable of loading
78      * classes from the Agent's MobileCodebase
79      */
80     public ConduitObjectInputStream(InputStream is, ConduitServerClassLoader classLoader)
81         throws IOException, StreamCorruptedException {
82         super(is);
83
84         itsClassLoader = classLoader;
85
86     }
87
88     /**
89      * Resolves a fully qualified class name to a Class object. resolveClass uses a
90      * ConduitServerClassLoader to actually perform the class loading.
91      * @param classname The classes fully qualified class name.
92      */
93     protected Class resolveClass(String classname)
94         throws IOException, ClassNotFoundException {

```

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```
ConduitObjectOutputStream.java_1      Tue Nov 12 07:45:02 1996      2

48  public ConduitObjectOutputStream(OutputStream is)
49      throws IOException {
50      super(is);
51  }
52
53  protected void annotateClass(Class cl) throws IOException {
54      Debug.println("conduit.classload", 3, "ConduitObjectOutputStream.annotateClass called for " + cl);
55  }
56
57 }
```



```

ConduitServer.java_1      Tue Nov 12 07:45:02 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/ConduitServer.java 9 11/11/96 5:15p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Conduit Server distributed interface
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/conduit/ConduitServer.java $
13  *
14  * 9 11/11/96 5:15p Billp
15  * Made correction to company name.
16  *
17  * 8 9/30/96 7:06p Walsh
18  * clean up javadoc comments
19  *
20  * 7 8/27/96 3:51p Walsh
21  * remove getConduitName method from ConduitServer interface
22  *
23  * 6 8/22/96 5:45p Walsh
24  * Move the custom marshalling of the agent into the AgentPackage class
25  *
26  * 5 8/19/96 5:26p Walsh
27  * Add support for remote class loading
28  *
29  * 4 8/13/96 11:47a Walsh
30  * Add documentation & comments. Change signature of receivePackage
31  * method.
32  *
33  * 3 8/12/96 7:15p Walsh
34  * ConduitServer now performs Marshalling
35  *
36  * 2 8/09/96 4:38p Walsh
37  * Setting up file headers
38  */
39
40 package com.meitca.hsl.zonesjagents.conduit;
41
42 import java.rmi.Remote;
43 import java.rmi.RemoteException;
44
45 import com.meitca.hsl.zonesjagents.conduit.AgentPackage;
46 import com.meitca.hsl.zonesjagents.conduit.MobileCodebase;
47

```

- 105 -

ConduitServer.java\_1 Tue Nov 12 07:45:02 1996 2

```
48 /**
49  * ConduitServer is an RMI distributed interface. It provides some RMI glue
50  * that allows conduit servers to communicate. ConduitServer is implemented
51  * by the ConduitServerImpl class. Conduit servers provide for Agent travel
52  * and execution
53  * @see ConduitServerImpl
54  * @author Thomas Walsh
55  */
56 public interface ConduitServer extends Remote {
57
58     /**
59      * Receive an Agent from the previous conduit server in its Itinerary.
60      * @param aPackage The package containing the agents, its mobile
61      * codebase and its itinerary.
62      * @exception RemoteException If a communication error occurs
63      */
64     public void receivePackage(AgentPackage aPackage)
65         throws RemoteException;
66
67 }
```

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```

ConduitServerClassLoader.java_1      Tue Nov 12 07:45:02 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/ConduitServerClassLoader.java 12 11/11/96 5:15p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Conduit Server ClassLoader subclass
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/conduit/ConduitServerClassLoader.java $
13  *
14  * 12 11/11/96 5:15p Billp
15  * Made correction to company name.
16  *
17  * 11 11/01/96 5:32p Walsh
18  * Modify debugging levels of debug output
19  *
20  * 10 10/24/96 5:15p Walsh
21  * add some debugging information related to memory usage.
22  *
23  * 9 10/21/96 4:26p Walsh
24  * Add debug logging
25  *
26  * 8 9/30/96 7:06p Walsh
27  * clean up javadoc comments
28  *
29  * 7 9/28/96 6:37p Walsh
30  * use the AgentCodebase class to retrieve bytecodes
31  *
32  * 6 8/22/96 5:42p Walsh
33  * Cache Classes we define
34  *
35  * 5 8/19/96 5:25p Walsh
36  *
37  * 4 8/13/96 5:09p Walsh
38  * Added comments & documentation. loadClass now looks in MobileCodebase.
39  *
40  * 3 8/13/96 11:19a Walsh
41  * remove obsolete loadMobileClasses method
42  *
43  * 2 8/09/96 4:38p Walsh
44  * Setting up file headers
45  */
46
47 package com.meitca.hsl.zonesjagents.conduit;

```

ConduitServerClassLoader.java\_1 Tue Nov 12 07:45:02 1996 2

```

48 import java.rmi.Naming;
49 import java.io.*;
50 import java.net.*;
51 import java.util.*;
52
53 import com.meitca.hsl.zones:jagents.shared.*;
54 import com.meitca.hsl.util.*;
55
56 /**
57  * A specialized ClassLoader object used by the conduit server to manage agent
58  * creation, deserialization, and sub-object creation. ConduitServerClassLoader
59  * extends the base system class loading behavior by allowing for classes to be
60  * loaded from the MobileCodebase of an Agent. For example, an Agent object might
61  * be created on one particular server on a network. When it is created, its
62  * bytecodes are added to the MobileCodebase. The agent now travels to a new
63  * server. The bytecodes for this particular agent have not been installed on the
64  * new server. Under normal circumstances, when the object deserialization code
65  * attempts to reconstruct the agent, a ClassNotFoundException would result since
66  * the agents code does not exist anywhere on the new server.
67  * ConduitServerClassLoader allows the Java virtual machine to look for an Agents
68  * code in the MobileCodebase which allows Agent object to travel and pull their
69  * code with them.
70  *
71  * @see Agent
72  * @see ConduitServer
73  * @see MobileCodebase
74  * @see ClassLoader
75  * @author Thomas Walsh
76  */
77 public class ConduitServerClassLoader
78     extends ClassLoader {
79
80     /** The MobileCodebase corresponding to the Agent being managed. */
81     MobileCodebase itsMobileCodebase;
82
83     /** An URL back to the coibase of this agent on its home machine */
84     AgentCodebase itsHomeCodebase;
85
86     /**
87      * A hashtable containing the Class objects we have already
88      * defined during the serialization process
89      */
90     Hashtable itsPreviouslyDefinedClasses;
91
92     /**
93      * Constructs a ConduitServerClassLoader
94      * @param codebase The MobileCodebase corresponding to the

```

```

ConduitServerClassLoader.java_1      Tue Nov 12 07:45:02 1996      3

95  *
96  * @param      homeCodebaseURL An URL back to the codebase of this
97  *              agent on its home machine.
98  * @exception  MalformedURLException if the URL passed in as the
99  *              homeCodebaseURL parameter is invalid.
100  */
101  public ConduitServerClassLoader(MobileCodebase codebase, String homeCodebaseURL)
102  {
103      Debug.println("conduit.memory", 3, "ConduitServerClassLoader " + this + " created");
104      itsMobileCodebase = codebase;
105      itsHomeCodebase = new AgentCodebase(homeCodebaseURL);
106      itsPreviouslyDefinedClasses = new Hashtable();
107  }
108
109  protected void finalize() throws Throwable {
110      Debug.println("conduit.memory", 3, "ConduitServerClassLoader " + this + " finalized");
111      super.finalize();
112  }
113
114
115  /**
116   * Loads a class. First check on the local system and then looks in the
117   * MobileCodebase.
118   * @param      name Fully qualified name of the class to be loaded (ie <b>
119   *                  "java.lang.String"</b>).
120   */
121  public Class loadClass(String name)
122  {
123      throws ClassNotFoundException {
124          return loadClass(name, true);
125      }
126  }
127
128  /**
129   * Loads a class. Inherited from ClassLoader. First check on the local
130   * system and then looks in the MobileCodebase.
131   * @param      name Fully qualified name of the class to be loaded (ie
132   *                  java.lang.String.
133   * @param      resolve boolean value indicating whether or not the class
134   *                  should be resolved via the ClassLoader.resolveClass method
135   */
136  protected Class loadClass(String name, boolean resolve)
137  {
138      throws ClassNotFoundException {
139          Debug.println("conduit.classload", 2, "ConduitServerClassLoader.loadClass called for " + name);
140          Debug.println("conduit.classload", 2, "resolve is " + resolve);
141
142          // first check the cache to see if we have encountered this class
143          // before. Note: A ClassLoader object should always do something

```

ConduitServerClassLoader.java\_1

Tue Nov 12 07:45:02 1996

4

```

142 // like this. In order for Java's type checking to work properly,
143 // everytime a loadClass is called for a particular class name, the
144 // EXACT SAME Class object must be returned.
145 Class cache = (Class)itsPreviouslyDefinedClasses.get(name);
146 if (cache != null) {
147     Debug.println("conduit.classload", 3, "Class found in cache");
148     return cache;
149 }
150
151 try {
152     // first check this system
153     Class c = findSystemClass(name);
154     Debug.println("conduit.classload", 3, "Class found on system");
155     if (resolve) {
156         resolveClass(c);
157     }
158     return c;
159 } catch (ClassNotFoundException e) {
160     // wasn't found on this system. Check the MobileCodebase...
161     byte[] bytecodes = itsMobileCodebase.getCode(name);
162
163     if (bytecodes != null) {
164         Debug.println("conduit.classload", 3, "Class found in MobileCodebase");
165
166         // bytecodes for the class were found in the MobileCodebase.
167         // Try to define a class from them.
168         Class c = defineClass(bytecodes, 0, bytecodes.length);
169         if (resolve) {
170             resolveClass(c);
171         }
172
173         // store this class in the cache
174         itsPreviouslyDefinedClasses.put(name, c);
175         return c;
176     } else {
177         Debug.println("conduit.classload", 3, "Looking in home codebase");
178         return loadClassFromHomeCodebase(name, resolve);
179     }
180 }
181
182 /**
183  * Loads a class using the remote class loader.
184  * @param name Fully qualified name of the class to be loaded (ie
185  * java.lang.String.
186  * @param resolve boolean value indicating whether or not the class
187  *
188

```

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```

ConduitServerClassLoader.java_1      Tue Nov 12 07:45:02 1996      5

189      *
190      */
191      protected Class loadClassFromHomeCodebase(String name, boolean resolve)
192      throws ClassNotFoundException {
193
194          Debug.println("conduit.classload", 2, "ConduitServerClassLoader.loadClassFromHomeCodebase called for:
195      " + name);
196
197          Debug.println("conduit.classload", 2, "resolve is " + resolve);
198
199          byte[] bytecodes = itsHomeCodebase.retrieveCode(name);
200
201          // bytecodes for the class were found in at remote location.
202          // store them in the MobileCodebase for future reference
203          itsMobileCodebase.storeCode(name, bytecodes);
204
205          // Try to define a class from them.
206          Class c = defineClass(bytecodes, 0, bytecodes.length);
207          if (resolve) {
208              resolveClass(c);
209          }
210          // store this class in the cache
211          itsPreviouslyDefinedClasses.put(name, c);
212
213          return c;
214      }

```

```

ConduitServerImpl.java_1      Tue Nov 12 07:45:02 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/ConduitServerImpl.java 23 11/11/96 5:15p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Conduit Server implementation
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/conduit/ConduitServerImpl.java $
13  *
14  * 23 11/11/96 5:15p Billp
15  * Made correction to company name.
16  *
17  * 22 10/30/96 2:52p Walsh
18  * Allow Debug and ErrorLog settings to be set in properties file
19  *
20  * 21 10/29/96 5:28p Walsh
21  * Use ErrorLog class to report errors
22  *
23  * 20 10/28/96 6:31p Walsh
24  * Add more debugging info
25  *
26  * 19 10/25/96 5:02p Walsh
27  * Make AgentThread public. Move to own source file.
28  *
29  * 18 10/24/96 5:15p Walsh
30  * add some debugging information related to memory usage.
31  *
32  * 17 10/23/96 2:22p Walsh
33  * add more Debug.println's
34  *
35  * 16 10/21/96 4:26p Walsh
36  * Add debug logging
37  *
38  * 15 10/11/96 2:20p Walsh
39  * remove restarted agents from persistence store
40  *
41  * 14 10/10/96 6:02p Walsh
42  * Add persistence support
43  *
44  * 13 9/29/96 4:08p Walsh
45  * Allow Destination methods to be specified by name
46  * Give Agent access to AgentPackage information
47  *

```



```

ConduitServerImpl.java_1      Tue Nov 12 07:45:02 1996      2

48 * 12   9/09/96 6:02p Walsh
49 * make constant final
50 *
51 * 11   9/04/96 12:32p Walsh
52 * Centralize manipulation of ConduitServer's RMI URL.
53 * Move test security manager out of this file.
54 *
55 * 10   8/30/96 3:53p Walsh
56 * null out itsPackage (in AgentThread.run) to try to nudge the garbage
57 * collector
58 *
59 * 9    8/23/96 3:58p Walsh
60 * Add support for ad-hoc method invocation
61 *
62 * 8    8/22/96 6:35p Walsh
63 * Add static reference to the one ConduitServer that exists.
64 *
65 * 7    8/22/96 5:45p Walsh
66 * Move the custom marshalling of the agent into the AgentPackage class
67 *
68 * 6    8/19/96 5:26p Walsh
69 * Add support for remote class loading
70 *
71 * 5    8/13/96 5:12p Walsh
72 * Changed signature of receivePackage. Changed marshalling.
73 * un-marshalling code to marshal only Agent and not entire AgentPackage
74 *
75 * 4    8/13/96 10:35a Walsh
76 * Add some comments and documentation
77 *
78 * 3    8/12/96 7:16p Walsh
79 * ConduitServer now performs Marshalling
80 *
81 * 2    8/09/96 4:38p Walsh
82 * Setting up file headers
83 */
84 package com.meitca.hsl.zonesjagents.conduit;
85
86 import java.rmi.server.UnicastRemoteServer;
87 import java.rmi.RemoteException;
88 import java.rmi.Naming;
89 import java.rmi.NotBoundException;
90 import java.net.*;
91 import java.io.*;
92 import java.util.*;
93
94 import com.meitca.hsl.zonesjagents.shared.*;

```

```

ConduitServerImpl.java_1      Tue Nov 12 07:45:02 1996      3

95 import com.meitca.hsl.util.*;
96 import com.meitca.hsl.zonesagents.security.InsecurityManager;
97
98 /**
99  * An RMI distributed object which provides for Agent travel and execution.
100  * ConduitServerImpl implements the ConduitServer interface. ConduitServer
101  * is an RMI distributed interface. ConduitServerImpl is responsible for
102  * receiving incoming agents, providing for execution of agents, and for
103  * transmitting agents to other destinations.
104  * @see Agent
105  * @see ConduitServer
106  * @author Thomas Walsh
107  */
108 public class ConduitServerImpl
109     extends UnicastRemoteServer
110     implements ConduitServer {
111
112     /**
113      * The conduit server is a Sentinel object. There will only be one of
114      * them running within a given Java virtual machine. The static member
115      * theServer is a pointer to that one ConduitServerImpl object
116      */
117     static ConduitServerImpl theServer;
118
119     /** The conduit servers name. */
120     String
121         itsName;
122
123     /** The conduit servers properties file */
124     JASProperties
125         itsProperties;
126
127     /** An object representing the servers persistence store */
128     ConduitServerPersistenceStore itsPersistenceStore;
129
130     /** String constants. */
131     /** The name to which a conduit server is bound in the RMI Registry */
132     static final String RMI_NAME = "ConduitServer";
133     static final String PROP_DESC = "Properties File for Conduit Server";
134
135     /**
136      * The following member variables store some statistical information
137      * about the performance of the Conduit Server.
138      */
139     /** The date and time when this Conduit Server was started */
140     Date itsStartTime;
141     /** The number of Agents currently in the system */

```

```

ConduitServerImpl.java_1      Tue Nov 12 07:45:02 1996      4

142     long
143
144     /**
145      * The total number of Agents to travel through the system
146      * since startup
147      */
148     long
149
150     /**
151      * The largest number of Agent to be in the system at any one time.
152      */
153     long
154
155
156
157
158     /**
159      * Constructs a conduit server
160      * @param name The servers name.
161      * @exception RemoteException If an error occurs setting up network
162      *          communications
163      */
164     public ConduitServerImpl(String name) throws RemoteException {
165         itsName = new String(name);
166         theServer = this;
167
168         // initialize the counters
169         itsTotalAgentCount = 0;
170         itsCurrentAgentCount = 0;
171         itsPeakAgentCount = 0;
172
173         try {
174             itsProperties = new JASProperties(RMI_NAME,
175
176                                     JASProperties.SERVER,
177                                     PROP_DESC,
178                                     false);
179
180             ) catch (Exception e) {
181                 ErrorLog.println("conduit.ConduitServerImpl", ErrorLog.SEVERITY.WARNING,
182                                 "Could not access Properties file for Conduit Server
183                                 ErrorLog.println("conduit.ConduitServerImpl", ErrorLog.SEVERITY.WARNING,
184                                                 "Continuing with defaults.", e);
185
186                 // Construct an empty Properties object.
187                 itsProperties = new JASProperties();
188
189             // Set up the debug and error logging facilities using the
190             // Conduit Server specific properties.

```

```

ConduitServerImpl.java_1      Tue Nov 12 07:45:02 1996      5

189     Debug.enable(itsProperties);
190     ErrorLog.initialize(itsProperties);
191
192     itsPersistenceStore = new ConduitServerPersistenceStore();
193
194 }
195
196 /**
197  * Send the Agent on to the next conduit server in its Itinerary.
198  * @param agentPackage The Agent Package containing the Agent.
199  * @exception NoSuchElementException If the agent has completed its
200  *           Itinerary.
201  * @exception RemoteException If an error occurs communicating with
202  *           the next server.
203  * @exception NotBoundException If the server name indicated as the
204  *           next destination in the Itinerary cannot be found on the
205  *           network.
206  */
207     public static void sendPackage(AgentPackage agentPackage)
208     throws NoSuchElementException, IOException,
209            RemoteException, NotBoundException{
210
211         // retrieve a remote reference to the next destination
212         ConduitServer nextConduit = (ConduitServer)Naming.lookup(
213             buildRmiURL(agentPackage.getItinerary().nextDestination().getDestinationHost.
214             ));
215
216         agentPackage.prepareForTransport();
217
218         // pass the agent along
219         nextConduit.receivePackage(agentPackage);
220     }
221
222 /**
223  * Receive an Agent from the previous conduit server in its Itinerary.
224  * @param agentData A stream of bytes containing the serialized
225  *           agent.
226  * @param codebase The agents MobileCodebase
227  * @param itinerary The agents Itinerary
228  * @exception RemoteException If an error occurs communicating with
229  *           the prior server.
230  */
231     public void receivePackage(AgentPackage agentPackage)
232     throws RemoteException {
233         Debug.println("conduit", 2, "ConduitServerImpl.receivePackage called");
234         agentPackage.restoreFromTransportForm();

```

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```

ConduitServerImpl.java_1      Tue Nov 12 07:45:02 1996      6

235     Debug.println("conduit", 1, "Agent " + agentPackage.getAgent().getAgentID() + " has arrived");
236
237     incrementAgentCounters();
238
239     AgentThread newThread = new AgentThread(agentPackage);
240
241 }
242
243 static public void restartAgent(AgentPackage agentPackage) {
244     Debug.println("conduit", 1, "Restarting Agent " + agentPackage.getAgent().getAgentID());
245     incrementAgentCounters();
246
247     try {
248         if (agentPackage.getItinerary().getCurrentLocation().hasCompleted()) {
249             Debug.println("conduit", 1, "\tAgent had completed execution on this Conduit Server."
250
251
252             Debug.println("conduit", 1, "\tSending Agent to next Destination");
253
254             decrementAgentCounters();
255             sendPackage(agentPackage);
256
257             // remove the agent from the persistence store
258             getPersistenceStore().removeFromStore(agentPackage);
259
260         } else {
261             Debug.println("conduit", 1, "\tAgent had not completed execution on this Conduit Se:
262
263             Debug.println("conduit", 1, "\tRestarting execution");
264             AgentThread newThread = new AgentThread(agentPackage);
265
266         } catch (Exception e) {
267             ErrorLog.println("conduit.ConduitServerImpl",
268                             ErrorLog.SEVERITY_ERROR,
269                             "An error occurred while restarting agent:",
270                             e);
271
272         }
273
274     }
275
276     /**
277     * Retrieves a property from the Conduit Server
278     * @param key The name of the property to retrieve
279     * @param def A default value which will be returned if
280     *             the property cannot be found
281     * @return the property value (a string)
282     */
283     public static String getProperty(String key, String def) {
284         return theServer.getProperties().getProperty(key, def);
285     }

```

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```
ConduitServerImpl.java_1      Tue Nov 12 07:45:02 1996      7

    280     )
    281
    282     /**
    283      * Returns the conduit servers name.
    284      * @exception RemoteException If any network error occurs.
    285      */
    286     public static String getConduitName() throws RemoteException {
    287         return theServer.itsName;
    288     }
    289
    290
    291     /**
    292      * This method is used internally to build a full RMI URL for a conduit
    293      * server on the given host.
    294      */
    295     protected static String buildRmiURL(String hostname) {
    296         return new String("rmi://" + hostname + "/" + RMI_NAME);
    297     }
    298
    299
    300     /**
    301      * Returns a refernece to the conduit servers persistence store.
    302      */
    303     public static ConduitServerPersistenceStore getPersistenceStore() {
    304         return theServer.itsPersistenceStore;
    305     }
    306
    307     /**
    308      * Returns the startup time of this conduit server.
    309      */
    310     public static Date getStartupTime() {
    311         return theServer.itsStartTime;
    312     }
    313
    314     /**
    315      * Returns the uptime of this conduit server (in milliseconds).
    316      */
    317     public static long getUptime() {
    318         return (System.currentTimeMillis() - theServer.itsStartTime.getTime());
    319     }
    320
    321     /**
    322      * Returns the total number of agents to pass through this
    323      * Conduit Server since it was started.
    324      */
    325     public static long getTotalAgentCount() {
    326         return theServer.itsTotalAgentCount;
    327     }
    328 }
```

```

ConduitServerImpl.java_1      Tue Nov 12 07:45:02 1996      8

327     }
328
329     /**
330      * Returns the number of agents currently executing
331      * in this Conduit Server.
332      */
333     public static long getCurrentAgentCount() {
334         return theServer.itsCurrentAgentCount;
335     }
336
337     /**
338      * Returns the maximum number of agents to be executing
339      * at any one time in this Conduit Server.
340      */
341     public static long getPeakAgentCount() {
342         return theServer.itsPeakAgentCount;
343     }
344
345
346
347     /**
348      *
349      */
350     public static synchronized void incrementAgentCounters() {
351         if (theServer != null) {
352             theServer.itsTotalAgentCount++;
353             theServer.itsCurrentAgentCount++;
354             if (theServer.itsCurrentAgentCount > theServer.itsPeakAgentCount)
355                 theServer.itsPeakAgentCount = theServer.itsCurrentAgentCount;
356         }
357     }
358
359     /**
360      *
361      */
362     public static synchronized void decrementAgentCounters() {
363         if (theServer != null) {
364             theServer.itsCurrentAgentCount--;
365         }
366     }
367
368     /**
369      * Performs server startup tasks
370      */
371     void startup() {
372         itsPersistenceStore.restorePersistedObjects();
373         // Monitor memory if conduit.memory facility is set to

```

ConduitServerImpl.java\_1 Tue Nov 12 07:45:02 1996 9

```

374 // debug level 4
375 if (Debug.enabled("conduit.memory.watch", 4)) {
376     MemoryWatch watch = new MemoryWatch();
377 }
378
379     itsStartTime = new Date();
380 }
381
382 /**
383  * A simple bootstrap which brings the conduit server into existence,
384  * registers it name with the RMI naming service and begins listening
385  * for Agent requests. The main routine allows ConduitServerImpl to
386  * be initiated from the command line via the java command.
387  */
388 public static void main(String args[]) {
389     // Create and install the security manager
390     //System.setSecurityManager(new StubSecurityManager());
391     System.setSecurityManager(new InsecurityManager());
392
393     try {
394         // construct the server and register it with the RMI Naming service
395         Debug.println("conduit", 1, "Create an Conduit Server");
396         String url = buildRmiURL(InetAddress.getLocalHost().getHostName());
397
398         ConduitServerImpl server = new ConduitServerImpl(url);
399
400         Debug.println("conduit", 1, "Bind it to name: " + RMI_NAME);
401         Naming.rebind(RMI_NAME, server);
402
403         server.startup();
404         Debug.println("conduit", 1, "Conduit Server ready.");
405     } catch (Exception e) {
406         ErrorLog.println("conduit.main", ErrorLog.SEVERITY_FATAL,
407             "an exception occurred during startup.", e);
408     }
409 }
410

```



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```

ConduitServerPersistenceStore.java_1      Tue Nov 12 07:45:02 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/ConduitServerPersistenceStore.java 6 11/11/96 5:15p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Conduit Server Persistence Store
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/conduit/ConduitServerPersistenceStore.java $
13  *
14  * 6 11/11/96 5:15p Billp
15  * Made correction to company name.
16  *
17  * 5 10/29/96 5:29p Walsh
18  * Use ErrorLog class to report errors
19  *
20  * 4 10/21/96 4:26p Walsh
21  * Add debug logging
22  *
23  * 3 10/21/96 11:38a Walsh
24  * mirror change in Persistence API
25  *
26  * 2 10/18/96 10:58a Walsh
27  * synch with change to findObject API
28  *
29  * 1 10/10/96 6:01p Walsh
30  * initial version
31  *
32  */
33 package com.meitca.hsl.zonesjagents.conduit;
34
35 import java.io.File;
36 import java.util.*;
37
38 import com.meitca.hsl.zonesjagents.persistence.*;
39 import com.meitca.hsl.zonesjagents.shared.*;
40 import com.meitca.hsl.util.*;
41
42 /**
43  * Conduit Server Persistence Store
44  * @see ConduitServerImpl
45  * @author Thomas Walsh
46  */
47 class ConduitServerPersistenceStore {

```

ConduitServerPersistenceStore.java\_1 Tue Nov 12 07:45:02 1996 2

```

48 // String constants representing the property names of
49 // two properties of interest
50 private static final String ENABLE_PERSISTENCE = "conduit.persistence.Enable";
51 private static final String PERSISTENCE_FILE = "conduit.persistence.FileName";
52 private static final String DEFAULT_FILENAME = "persist.store";
53
54 /** The PersistentStoreManager object used to manager the persistence store */
55 PersistentStoreManager itsStore;
56
57 /**
58  * Constructs the PersistenceStore. Persistence will be enabled only
59  * if the conduit.persistence.Enable Property is set to "true". The
60  * PersistenceStore will be stored in the file named in the
61  * conduit.persistence.FileName property. If this Property is not set,
62  * the store will be placed in the file "zones.home/Agent/persist.store"
63  * only
64  */
65 ConduitServerPersistenceStore() {
66     if (new Boolean(ConduitServerImpl.getProperty(ENABLE_PERSISTENCE, "false")).booleanValue()) {
67         Debug.println("conduit.persistence", 1, "Persistence enabled.");
68
69         String filename = ConduitServerImpl.getProperty(PERSISTENCE_FILE, "");
70         Debug.println("conduit.persistence", 3, "conduit.persistence.FileName property set to " + filename);
71     }
72     if (filename.length() == 0) {
73         filename = AgentConstants.AGENT_DIR + DEFAULT_FILENAME;
74     }
75
76     try {
77         // construct the PersistentStoreManager
78         Debug.println("conduit.persistence", 2, "Persistence filename is " + filename);
79         itsStore = new PersistentStoreManager(filename);
80     } catch (PersistentStoreException e) {
81         ErrorLog.println("conduit.Persistence", "ErrorLog.SEVERITY_ERROR,
82             "An error occurred constructing the persistence
83             store.", e);
84         ErrorLog.println("conduit.Persistence", "ErrorLog.SEVERITY_WARNING,
85             "Continuing without persistence.");
86
87         // null out the itsStore reference. We will continue
88         // executing with persistence disabled
89         itsStore = null;
90     }
91 } else {
92     // null out the itsStore reference. This will

```



```

ConduitServerPersistenceStore.java_1      Tue Nov 12 07:45:02 1996      4

NING,
132
133
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175

    "Continuing without persistence.");
    // null out the itsStore reference. We will continue
    // executing with persistence disabled
    itsStore = null;
}
    ) catch (PersistentStoreException e2) {
        ErrorLog.println("conduit.Persistence", ErrorLog.SEVERITY_ERROR,
            "An error occurred adding agent " + aPackage.
                " to the persistence store.", e2);

        ErrorLog.println("conduit.Persistence", ErrorLog.SEVERITY_WARNING,
            "Continuing without persistence.");

        // null out the itsStore reference. We will continue
        // executing with persistence disabled
        itsStore = null;
    }
    ; catch (PersistentStoreException e3) {
        ErrorLog.println("conduit.Persistence", ErrorLog.SEVERITY_ERROR,
            "An error occurred adding agent " + aPackage.getAgent
                " to the persistence store.", e3);

        ErrorLog.println("conduit.Persistence", ErrorLog.SEVERITY_WARNING,
            "Continuing without persistence.");

        // null out the itsStore reference. We will continue
        // executing with persistence disabled
        itsStore = null;
    }
}

    /**
     * Updates an AgentPackage in the persistence store.
     * @param aPackage The package to add.
     */
    void updateStore(AgentPackage aPackage) {
        if (itsStore != null) {
            Debug.println("conduit.persistence", 3, "Updating agent in persistence store: " + aPackage);
            Debug.println("conduit.persistence", 3, "Agent's oid is : " + aPackage.getOID());
        }
        try {

```

```

ConduitServerPersistenceStore.java_1      Tue Nov 12 07:45:02 1996      5

176         itsStore.updateObject(aPackage.getOID(), aPackage);
177     } catch (PersistentStoreException e2) {
178         ErrorLog.println("conduit.Persistence", ErrorLog.SEVERITY_ERROR,
179             "An error occurred updating agent " + aPackage.getAgent().get
180             AgentID() +
181             " in the persistence store.", e2);
182         ErrorLog.println("conduit.Persistence", ErrorLog.SEVERITY_WARNING,
183             "Continuing without persistence.");
184     }
185     // null out the itsStore reference. We will continue
186     // executing with persistence disabled
187     itsStore = null;
188 }
189
190
191
192
193 /**
194  * Removes an AgentPackage to the persistence store.
195  * @param aPackage The package to remove.
196  */
197 void removeFromStore(AgentPackage aPackage) {
198     if (itsStore != null) {
199         Debug.println("conduit.persistence", 3, "Removing agent from persistence store: " + aPackage.get
200         AgentID() +
201         " from the persistence store.", e);
202         Debug.println("conduit.persistence", 3, "Agent's oid is : " + aPackage.getOID());
203     }
204     try {
205         itsStore.deleteObject(aPackage.getOID());
206     } catch (PersistentStoreException e) {
207         ErrorLog.println("conduit.Persistence", ErrorLog.SEVERITY_ERROR,
208             "An error occurred removing agent " + aPackage.getAgent().get
209             AgentID() +
210             " from the persistence store.", e);
211         ErrorLog.println("conduit.Persistence", ErrorLog.SEVERITY_WARNING,
212             "Continuing without persistence.");
213     }
214     // null out the itsStore reference. We will continue
215     // executing with persistence disabled
216     itsStore = null;
217 }
218
219 /**

```

ConduitServerPersistenceStore.java\_1 Tue Nov 12 07:45:02 1996 6

```

220 * Restores all Agents in the Persistence Store and
221 * passes them into the ConduitServerImpl.restartAgent method
222 * so that they are restarted.
223 */
224 void restorePersistedObjects() {
225     if (itsStore != null) {
226         Debug.println("conduit.persistence", 3, "Restoring all persisted Agents");
227
228         Enumeration enum = itsStore.getOIDs();
229
230         while (enum.hasMoreElements()) {
231             ObjectID objectID = (ObjectID)enum.nextElement();
232             int oid = objectID.getOID();
233
234             Debug.println("conduit.persistence", 4, "Restoring Agent.  Oid is : " + oid);
235
236             if (oid != 0) {
237                 try {
238                     AgentPackage aPackage = (AgentPackage)itsStore.fetchObject(oid);
239                     Debug.println("conduit.persistence", 4, "Agent Package is : " + aPackage);
240
241                     aPackage.setOID(oid);
242                     ConduitServerImpl.restartAgent(aPackage);
243                 } catch (PersistentStoreException e) {
244                     ErrorLog.println("conduit.persistence", ErrorLog.SEVERITY_ERROR,
245                                     "An error occurred restoring persisted Agents: "
246                                     + e);
247
248                     ErrorLog.println("conduit.persistence", ErrorLog.SEVERITY_WARNING,
249                                     "Continuing without persistence.");
250
251                     // null out the itsStore reference. We will continue
252                     // executing with persistence disabled.
253                     itsStore = null;
254                 }
255             }
256         }
257     }
258 }

```

```

Destination.java_1      Tue Nov 12 07:45:03 1996      1      11/11/96 5:15p Billp S
1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/Destination.java 7
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * An agents destination. Contains RMI URL of conduit server, and
11 * method id of method to invoke at that location
12 *
13 * $Log: /com/meitca/hsl/zonesjagents/conduit/Destination.java $
14 *
15 * 7 11/11/96 5:15p Billp
16 * Made correction to company name.
17 *
18 * 6 10/10/96 6:02p Walsh
19 * Add persistence support
20 *
21 * 5 9/30/96 7:06p Walsh
22 * clean up javadoc comments
23 *
24 * 4 9/29/96 4:08p Walsh
25 * Allow Destination methods to be specified by name
26 * Give Agent access to AgentPackage information
27 *
28 * 3 9/04/96 12:31p Walsh
29 * Destination now holds only the hostname of the ConduitServer, not the
30 * entire RMI URL
31 *
32 * 2 8/29/96 5:16p Walsh
33 * add default constructor and set* methods
34 *
35 * 1 8/23/96 3:50p Walsh
36 * Initial versions
37 */
38 package com.meitca.hsl.zonesjagents.conduit;
39
40 import com.meitca.hsl.zonesjagents.conduit.InvalidMethodNameException;
41
42 /**
43 * An object representing a Destination in an Agents Itinerary. The
44 * Destination is composed of two parts: <br>
45 * <ol>
46 * <li>the hostname of the conduit server in which to travel
47 * <li>An identifier indicating the method of the agent to call

```

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```

Destination.java_1      Tue Nov 12 07:45:03 1996      2

48  *      at that ConduitServer. This identifier can either be an
49  *      number representing a (zero based) ID of the method or the
50  *      name of the method in the form of a String.
51  *      </ol>
52  *      Agent
53  *      ConduitServer
54  *      Itinerary
55  *      Thomas Walsh
56  */
57  public class Destination implements Cloneable {
58      static final int UNKNOWN_METHOD_ID = -1;
59
60      /** The hostname of the Conduit Server in which to travel */
61      String itsHostName;
62
63      /** The method ID number of the method to invoke */
64      int itsMethodID;
65
66      /** The name of the method to invoke */
67      String itsMethodName;
68
69      /**
70       * A boolean indicating whether execution at this destination
71       * has completed.
72       */
73      boolean itsHasCompleted;
74
75      /**
76       * Constructs a Destination object.
77       * @param hostname The hostname of the conduit server in which to
78       * travel
79       * @param methodName The name of the method to invoke
80       */
81      public Destination(String hostname, String methodName) {
82          itsHostName = hostname;
83          itsMethodID = UNKNOWN_METHOD_ID;
84          itsMethodName = methodName;
85          itsHasCompleted = false;
86      }
87
88      /**
89       * Constructs a Destination object. This constructor is used
90       * internally to construct a Destination.
91       * @param hostname The hostname of the conduit server in which to
92       * travel
93       * @param methodID The method ID number of the method to invoke
94

```



Destination.java\_1      Tue Nov 12 07:45:03 1996      3

```

95  */
96  public Destination(String hostname, int method) {
97      itsHostName = hostname;
98      itsMethodID = method;
99      itsMethodName = null;
100     itsHasCompleted = false;
101 }
102
103 /**
104  * Construct an empty Destination object
105  */
106 public Destination() {
107     itsHostName = new String("");
108     itsMethodID = UNKNOWN_METHOD_ID;
109     itsMethodName = null;
110     itsHasCompleted = false;
111 }
112
113 /**
114  * Retrieves the hostname of the conduit server in which to travel
115  */
116 public String getDestinationHost() {
117     return itsHostName;
118 }
119
120 /**
121  * Retrieves the method ID number of the method to invoke
122  */
123 public int getMethodID() {
124     return itsMethodID;
125 }
126
127 /**
128  * Sets the URL of the conduit server in which to travel
129  */
130 public void setDestinationHost(String hostname) {
131     itsHostName = hostname;
132 }
133
134 /**
135  * Sets the method ID number of the method to invoke
136  */
137 public void setMethodID(int id) {
138     itsMethodName = null;
139     itsMethodID = id;
140 }
141

```

```

Destination.java_1      Tue Nov 12 07:45:03 1996      4

142  /**
143   * Retrieves the method name of the method to invoke
144   */
145  public String getMethodName() {
146      return itsMethodName;
147  }
148
149  /**
150   * Makes a clone of the Destination object
151   */
152  public Destination cloneDestination() {
153      Destination clone = new Destination();
154      clone.itsHostName = itsHostName;
155      clone.itsMethodID = itsMethodID;
156      clone.itsMethodName = itsMethodName;
157      return clone;
158  }
159
160  /**
161   * Sets the internal state of the Destination to
162   * indicate that execution has been completed.
163   */
164  void setCompleted() {
165      itsHasCompleted = true;
166  }
167
168  /**
169   * Checks the internal state of the Destination to
170   * see if execution has been completed.
171   */
172  boolean hasCompleted() {
173      return itsHasCompleted;
174  }
175
176  /** Used internally to convert a method name into a method id. */
177  protected void convertNameToId(AgentsSkeleton skel)
178      throws InvalidMethodNameException {
179      if (itsMethodName == null) {
180          throw new InvalidMethodNameException("No name specified for destination");
181      }
182      String[] methods = skel.getMethods();
183      for(int i=0; i<methods.length; i++) {
184          if (itsMethodName.equals(methods[i])) {
185              itsMethodID = i;
186              itsMethodName = null;
187          }
188      }

```



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```

InvalidMethodNameException.java_1      Tue Nov 12 07:45:03 1996      1
1  /*      $Header: /com/meitca/hsl/zonesjagents/conduit/InvalidMethodNameException.java 3      11/11/96 5:15p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Exception indicating that Method Name speicified in a Destination
11 * is not a valid name
12 *
13 *      $Log: /com/meitca/hsl/zonesjagents/conduit/InvalidMethodNameException.java $
14 *
15 *      3      11/11/96 5:15p Billp
16 *      Made correction to company name.
17 *
18 *      2      9/30/96 7:06p Walsh
19 *      clean up javadoc comments
20 *
21 *      1      9/29/96 4:07p Walsh
22 *      initial version
23 *
24 */
25 package com.meitca.hsl.zonesjagents.conduit;
26
27 /**
28 * An exception which indicates that the method name that was specified
29 * in a Destination was not the name of a method of the agent which
30 * is travelling.
31 * @see      Agent
32 * @see      AgentSkeleton
33 * @author    Thomas Walsh
34 */
35 public class InvalidMethodNameException extends Exception {
36     public InvalidMethodNameException() {
37         super();
38     }
39
40     public InvalidMethodNameException(String s) {
41         super(s);
42     }
43 }

```

```

Itinerary.java_1      Tue Nov 12 07:45:03 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/Itinerary.java 5 11/11/96 5:15p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Agent itinerary object
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/conduit/Itinerary.java 5
13 *
14 * 5 11/11/96 5:15p Billp
15 * Made correction to company name.
16 *
17 * 4 9/29/96 4:08p Walsh
18 * Allow Destination methods to be specified by name
19 * Give Agent access to Agen::Package information
20 *
21 * 3 8/23/96 3:58p Walsh
22 * Add support for ad-hoc method invocation
23 *
24 * 2 8/09/96 4:38p Walsh
25 * Setting up file headers
26 */
27 package com.meitca.hsl.zonesjagents.conduit;
28
29 import java.util.*;
30
31 /**
32 * An object representing an Agent's Itinerary. The Itinerary
33 * indicated WHERE an agent should travel and indicated WHAT
34 * the Agent should do at each stop
35 * @see Agent
36 * @see ConduitServer
37 * @see Destination
38 * @author Thomas Walsh
39 */
40 public class Itinerary {
41     Vector itsDestinations;
42     int itsCurrentStop;
43
44     /**
45      * Constructs an Itinerary object
46      */
47     public Itinerary() {

```

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```

Itinerary.java_1      Tue Nov 12 07:45:03 1996      2

48  itsDestinations = new Vector();
49  itsCurrentStop = -1;
50  }
51
52  /**
53   * Adds a new destination to the end of the Agents Itinerary.
54   * @param destination The new destination
55   */
56  public void addDestination(Destination destination) {
57      itsDestinations.addElement(destination);
58  }
59
60  /**
61   * Clears all destinations from the Agents Itinerary
62   */
63  public void clearItinerary() {
64      itsDestinations.removeAllElements();
65  }
66
67  /**
68   * Resets the Itinerary back to the initial Destination.
69   * This method could be used to force an Agent to restart
70   * its Itinerary and revisit all Destinations
71   */
72  public void resetItinerary() {
73      itsCurrentStop = -1;
74  }
75
76
77  /**
78   * Retrieves the destination object identifying the current
79   * location of the Agent
80   * @returns The Agent's current location
81   * @exception NoSuchElementException If the Agent has not
82   *         travelled.
83   */
84  public Destination getCurrentLocation() throws NoSuchElementException {
85      try {
86          return (Destination)itsDestinations.elementAt(itsCurrentStop);
87      } catch (ArrayIndexOutOfBoundsException | NoSuchElementException) {
88          throw new NoSuchElementException();
89      }
90  }
91
92  /**
93   * Retrieves the destination object identifying the current
94   * location of the Agent

```

```

Itinerary.java_1      Tue Nov 12 07:45:03 1996      3

95  * @returns          The Agent's next destination
96  * @exception      NoSuchElementException If the Agent has not
97  *                travelled.
98  */
99  public Destination getNextDestination() throws NoSuchElementException {
100      try {
101          return (Destination)itsDestinations.elementAt(itsCurrentStop+1);
102      } catch (ArrayIndexOutOfBoundsException boundError) {
103          throw new NoSuchElementException();
104      }
105  }
106
107  /**
108   * Retrieves an enumeration of all of the Destinations in the
109   * Itinerary.
110   * @returns      An enumeration of all of the Destinations in the
111   *              Itinerary.
112   */
113  public Enumeration destinations() {
114      return itsDestinations.elements();
115  }
116
117  /**
118   * Makes a clone of the Itinerary. If the reset parameter is true
119   * then the new Itinerary is reset to the first destination. If
120   * reset is false, then the new itinerary is set such that its next
121   * destination is the same as that of the original.
122   * @param  reset: true if the new itinerary should be reset to
123   *              the first destination.
124   * @returns A clone of the original Itinerary
125   */
126  public Itinerary cloneItinerary(boolean reset) {
127      Itinerary clone = new Itinerary();
128      Enumeration enum = itsDestinations.elements();
129      while (enum.hasMoreElements()) {
130          Destination original = (Destination)enum.nextElement();
131          Destination cloneDest = (Destination)original.cloneDestination();
132          clone.addDestination(cloneDest);
133      }
134      if (!reset)
135          clone.itsCurrentStop = itsCurrentStop;
136      return clone;
137  }
138
139  }
140
141

```

```
Itinerary.java_1      Tue Nov 12 07:45:03 1996      4

142  /**
143   * Retrieves the next destination to which an Agent should
144   * travel and increments the Itineraries internal state to
145   * the next destination. This method is called internally
146   * by the ConduitServer when it is preparing to transport
147   * the Agent to its next destination.
148   */
149  protected Destination nextDestination() throws NoSuchElementException {
150  try {
151      return (Destination)itsDestinations.elementAt(++itsCurrentStop);
152  } catch (ArrayIndexOutOfBoundsException boundError) {
153      throw new NoSuchElementException();
154  }
155  }
156  }
157  }
```



```

MemoryWatch.java_1      Tue Nov 12 07:45:03 1996      1      11/11/96 5:15p Billp $

1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/MemoryWatch.java 3
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Conduit Server implementation
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/conduit/MemoryWatch.java $
13 *
14 * 3 11/11/96 5:15p Billp
15 * Made correction to company name.
16 *
17 * 2 10/28/96 6:31p Walsh
18 * Add more debugging info
19 *
20 * 1 10/24/96 5:12p Walsh
21 * Initial Version
22 *
23 */
24 package com.meitca.hsl.zonesjagents.conduit;
25
26 import java.util.*;
27
28 import com.meitca.hsl.util.*;
29
30 /**
31 * The memory watch class provides an minimum priority thread which
32 * reports the total amount of memory allocated to the Java VM as
33 * well as the amount of free memory currently available.
34 *
35 * To enable the MemoryWatch, the Conduit Server should be started
36 * up with the following switch passed into java.exe
37 * -DDebug="conduit.memory.watch=4"
38 * @author Thomas Walsh
39 */
40 class MemoryWatch extends Thread {
41
42     /** The number of milliseconds between polls of the VM */
43     static int pollingInterval = 5000; // in millisec
44
45     /** Constructs a MemoryWatch object */
46     MemoryWatch() {
47         Debug.println("conduit.memory.watch", 1, "Memory Watch thread starting....");

```

MemoryWatch.java\_1 Tue Nov 12 07:45:03 1996 2

```

48      start();
49    }
50
51    /** Performs memory polling */
52    public void run() {
53        while (true) {
54            Debug.println("conduit.memory.watch", 4, "");
55            Debug.println("conduit.memory.watch", 4, "Server up since: " + ConduitServerImpl.getStartupTime());
56
57            long uptime = ConduitServerImpl.getUptime();
58            Date up_date = new Date(uptime);
59            Date bigBang = new Date(0);
60            Debug.println("conduit.memory.watch", 4, "Server uptime: " +
61                (up_date.getYear() - bigBang.getYear()) + " years, " +
62                (up_date.getMonth() - bigBang.getMonth()) + " months, " +
63                (up_date.getDate() - bigBang.getDate()) + " days, " +
64                (up_date.getHours() - bigBang.getHours()) + " hours, " +
65                (up_date.getMinutes() - bigBang.getMinutes()) + " minutes, "
66                +
67                (up_date.getSeconds() - bigBang.getSeconds()) + " seconds. ");
68
69            Debug.println("conduit.memory.watch", 4, "Total number of Agents:\t\t" + ConduitServerImpl
70                .getTotalAgentCount());
71            Debug.println("conduit.memory.watch", 4, "Current number of Agents:\t\t" + ConduitServerImpl
72                .getCurrentAgentCount());
73            Debug.println("conduit.memory.watch", 4, "Peak number of Agents:\t\t" + ConduitServerImpl
74                .getPeakAgentCount());
75            Debug.println("conduit.memory.watch", 4, "Total memory allocated to system:\t" + Runtime.ge
76                tRuntime().totalMemory());
77            Debug.println("conduit.memory.watch", 4, "Total free memory available:\t\t" + Runtime.getRun
78                time().freeMemory());
79            try {
80                sleep(pollingInterval);
81            } catch (InterruptedException e) {
82                Debug.println("conduit.memory.watch", 4, "Some thread interrupted the MemoryWatch du
83                ring sleep. Continuing");
84            }

```

```

MobileCodebase.java_1      Tue Nov 12 07:45:03 1996      1      11/11/96 5:15p Billp $
1  /* $Header: /com/meitca/hsl/zonesjagents/conduit/MobileCodebase.java 5
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Agent Mobile codebase object
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/conduit/MobileCodebase.java $
13 *
14 * 5 11/11/96 5:15p Billp
15 * Made correction to company name.
16 *
17 * 4 9/30/96 7:05p Walsh
18 * clean up javadoc comments
19 *
20 * 3 8/13/96 11:18a Walsh
21 * Add documentation & comments. Set up use of Hashtable for bytecode
22 * storage.
23 *
24 * 2 8/09/96 4:38p Walsh
25 * Setting up file headers
26 */
27 package com.meitca.hsl.zonesjagents.conduit;
28
29 import java.util.Hashtable;
30
31 /**
32 * Contains the by-codes, for the objects that travel with an Agent.
33 * @see Agent
34 * @author Thomas Walsh
35 */
36 public class MobileCodebase {
37     /**
38     * Provides for easy storage and retrieval of bytecodes. Bytecodes
39     * are stored in a Hashtable and are accessible by fully qualified
40     * Class name (ie "java.lang.String").
41     */
42     Hashtable itsByteCodes;
43
44     /**
45     * Constructs a MobileCodebase object
46     */
47

```

```
MobileCodebase.java_1      Tue Nov 12 07:45:03 1996      2

48     public MobileCodebase() {
49         itsByteCodes = new Hashtable();
50     }
51
52     /**
53      * Stores an objects bytecodes into the MobileCodebase.
54      * @param      name The fully qualified Class name (ie
55      *              <b>"java.lang.String"</b>).
56      * @param      code The Class's bytecodes
57      */
58     public void storeCode(String name, byte[] code) {
59         itsByteCodes.put(name, code);
60     }
61
62     /**
63      * Retrieves an objects bytecodes from the MobileCodebase.
64      * @param      name The fully qualified Class name (ie
65      *              <b>"java.lang.String"</b>).
66      */
67     public byte[] getCode(String name) {
68         return (byte[]) itsByteCodes.get(name);
69     }
70 }
```

```

RemoteClassLoader.java_1      Tue Nov 12 07:45:14 1996      1
1 /* $Header: /com/meitca/hsl/zonesjagents/remoteloader/RemoteClassLoader.java 4 11/11/96 5:15p Billp
2 *
3 * Copyright 1996 Horizon Systems Laboratory,
4 * Mitsubishi Electric Information Technology Center America.
5 * All rights reserved.
6 *
7 * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8 *
9 * DESCRIPTION
10 * Remote class loader distributed interface
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/remoteloader/RemoteClassLoader.java $
13 * 4 11/11/96 5:15p Billp
14 * Made correction to company name
15 *
16 *
17 * 3 9/28/96 6:39p Walsh
18 * Add new parameter to retrieveClass method
19 *
20 * 2 8/27/96 4:10p Walsh
21 * retrieveClass throws ClassNotFoundException (compiler games)
22 *
23 * 1 8/19/96 5:28p Walsh
24 * Initial version
25 */
26 package com.meitca.hsl.zonesjagents.remoteloader;
27
28 import java.rmi.Remote;
29 import java.rmi.RemoteException;
30
31
32 /**
33 * RemoteClassLoader is an RMI distributed interface. It provides a
34 * mechanism by which conduit servers can retrieve bytecodes for classes
35 * that exist on machines other than the one on which the conduit
36 * server is loading.
37 * @see ConduitServer
38 * @author Thomas Walsh
39 */
40 public interface RemoteClassLoader extends Remote {
41
42     /**
43      * Retrieve the bytecodes for the specified class.
44      * @param classURL An URL specifying the class to be loaded.
45      * This should be of the form /directory_path/classname
46      * @return The bytecodes for the class.
47      * @exception RemoteException If an error occurs communicating.

```

```
RemoteClassLoader.java_1      Tue Nov 12 07:45:14 1996      2

48      */
49      public byte[] retrieveClass(String codebaseURL, String className) throws RemoteException,
50      ClassNotFoundException:
51      )
```

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```

RemoteClassLoaderImpl.java_1      Tue Nov 12 07:45:14 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/remoteloader/RemoteClassLoaderImpl.java 8 11/11/96 5:15p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Remote class loader implementation
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/remoteloader/RemoteClassLoaderImpl.java $
13  *
14  * 8 11/11/96 5:15p Billp
15  * Made correction to company name
16  *
17  * 7 10/29/96 5:31p Walsh
18  * Use ErrorLog class to report errors
19  *
20  * 6 10/21/96 1:26p Walsh
21  * Add some debug output
22  *
23  * 5 9/28/96 6:40p Walsh
24  * Use AgentCodebase class to load byte codes.
25  * Add retrieveRemoteClass to encapsulate RMI code
26  *
27  * 4 9/04/96 12:33p Walsh
28  * Centralize manipulation or RMI URL. Use the test security manager
29  *
30  * 3 8/27/96 4:18p Walsh
31  * Add silly constructor (because Sun compiler wants it)
32  *
33  * 2 8/23/96 3:59p Walsh
34  * Add logging message
35  *
36  * 1 8/19/96 5:28p Walsh
37  * Initial version
38  */
39 package com.meitca.hsl.zonesjagents.remoteloader;
40
41 import java.rmi.Remote;
42 import java.rmi.RemoteException;
43 import java.rmi.server.UnicastRemoteServer;
44 import java.rmi.server.StubSecurityManager;
45 import java.rmi.Naming;
46 import java.io.*;
47 import java.lang.ClassNotFoundException;

```

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RemoteClassLoaderImpl.java\_1 Tue Nov 12 07:45:14 1996 2

```

48
49 import com.meitca.hsl.zonesjagents.security.*;
50 import com.meitca.hsl.zonesjagents.shared.*;
51 import com.meitca.hsl.util.*;
52
53
54 /**
55  * An RMI distributed object which provides for remote retrieval of class
56  * bytecodes. RemoteClassLoaderImpl implements the RemoteClassLoader interface.
57  * @see RemoteClassLoader
58  * @author Thomas Walsh
59  */
60 public class RemoteClassLoaderImpl
61     extends UnicastRemoteServer
62     implements RemoteClassLoader {
63
64     /**The name to which a conduit server is bound in the RMI Registry */
65     static String RMI_NAME = "RemoteClassLoader";
66
67     /**
68      * object which actually handles the dirty work or retrieving .class
69      * files for a given class.
70      */
71     ClassFileLoader
72         itsClassFileLoader;
73
74     public RemoteClassLoaderImpl() throws RemoteException {
75         itsClassFileLoader = new ClassFileLoader();
76     }
77
78     /**
79      * Retrieve the bytecodes for the specified class. This method is invoked
80      * by RMI. The calling program on the other side of the RMI connection
81      * usually invokes the RMI by calling the
82      * RemoteClassLoader.retrieveRemoteClass method below.
83      * @param classURL An URL specifying the class to be loaded.
84      * This should be of the form /directory_path/classname
85      * @return The bytecodes for the class.
86      * @exception RemoteException If an error occurs communicating.
87      */
88     public byte[] retrieveClass(String codebase_dir, String className)
89         throws RemoteException, ClassNotFoundException {
90         Debug.println("remote loader", 2, "loading " +
91             className + " from " + codebase_dir);
92         if ((codebase_dir == null) || (codebase_dir.length() == 0)) {
93             Debug.println("remote loader", 3, "loading from CLASSPATH");
94         }

```



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```

RemoteClassLoaderImpl.java_1      Tue Nov 12 07:45:14 1996      3

95         return itsClassLoader.loadClassFileFromClassPath(className);
96     } else {
97         Debug.println("remoteloader", 3, "loading from directory");
98         return itsClassLoader.loadClassFileFromDirectory(codebase_dir, className);
99     }
100 }
101
102 /**
103  * Retrieve the bytecodes for the specified class from the remote
104  * codebase specified by codebase_URL. This method is called internally
105  * by the Java agent system whenever an object wants to retrieve code
106  * from a RemoteClassLoader. This method hides the details of the RMI.
107  * @param codebase_URL An URL specifying the class to be loaded.
108  * This should be of the form /directory_path/classname
109  * @param className The fully qualified class name of the class whose
110  * bytecodes should be retrieved.
111  * @return The bytecodes for the class.
112  * @exception RemoteException If an error occurs communicating.
113  */
114 public static byte[] retrieveRemoteClass(String codebase_URL, String className)
115     throws ClassNotFoundException {
116     Debug.println("remoteloader", 2, "retrieveRemoteClass: loading " +
117         className + " from " + codebase_URL);
118     int count = 0;
119     int index = 0;
120     while (count < 4) {
121         index = codebase_URL.indexOf('/', index);
122         if (index == -1)
123             break;
124         count++;
125         index++;
126     }
127     String rmiURL;
128     String code_dir;
129     if (index != -1) {
130         rmiURL = codebase_URL.substring(0, (index - 1));
131         code_dir = codebase_URL.substring(index, codebase_URL.length());
132     } else {
133         rmiURL = codebase_URL;
134         code_dir = null;
135     }
136 }
137
138
139
140
141

```

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```

RemoteClassLoaderImpl.java_1      Tue Nov 12 07:45:14 1996      4

142 Debug.println("remoteloader", 3, "remote object URL: " + rmiURL);
143 Debug.println("remoteloader", 3, "remote code dir: " + code_dir);
144
145 try {
146     RemoteClassLoader remote = (RemoteClassLoader)Naming.lookup(rmiURL);
147     return remote.retrieveClass(code_dir, className);
148 }
149
150     catch (Exception e) {
151         throw new ClassNotFoundException("Could not load " + className + e.getMessage());
152     }
153
154
155
156 /**
157  * This method is used internally to build a full RMI URL for a remote
158  * class loader on the given host.
159  */
160 public static String buildRmiURL(String hostname) {
161     return new String("rmi://" + hostname + "/" + RMI_NAME);
162 }
163
164 /**
165  * This method is used internally to build a full RMI URL for a remote
166  * codebase on the given host.
167  */
168 public static String buildCodebaseURL(String hostname, String codeDir) {
169     return new String(buildRmiURL(hostname) + "/" + codeDir);
170 }
171
172 /**
173  * A simple bootstrap which brings the remote class loader into existence,
174  * registers it name with the RMI naming service and begins listening
175  * for requests. The main routine allows RemoteClassLoaderImpl to
176  * be initiated from the command line via the java command.
177  */
178 public static void main(String args[]) {
179     // Create and install the security manager
180     System.setSecurityManager(new InsecurityManager());
181
182     try {
183         // construct the server and register it with the RMI Naming service
184         Debug.println("remoteloader", 1, "Create an RemoteClassLoader");
185         RemoteClassLoaderImpl loader = new RemoteClassLoaderImpl();
186         Debug.println("remoteloader", 1, "Bind it to name: " + RMI_NAME);
187         Naming.rebind(RMI_NAME, loader);
188

```

```
RemoteClassLoaderImpl.java_1      Tue Nov 12 07:45:14 1996      5

189         Debug.println("remoteloader", 1, "RemoteClassLoaderImpl ready.");
190     } catch (Exception e) {
191         ErrorLog.println("remoteloader.main", ErrorLog.SEVERITY_FATAL,
192             "an exception occurred during startup:", e);
193     }
194 }
195 )
196
197 )
```

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```

Generator.java_1      Tue Nov 12 07:45:33 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/skeleton/Generator.java 5 11/11/96 5:16p Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Agent Skeleton Generator
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/skeleton/Generator.java $
13  *
14  * 5 11/11/96 5:16p Billp
15  * Made correction to company name
16  *
17  * 4 9/30/96 7:20p Walsh
18  * add javadoc comments
19  *
20  * 3 9/29/96 4:32p Walsh
21  * Allow agents to be in packages
22  *
23  * 2 9/12/96 11:00a Walsh
24  * Automatically compile the skeleton file
25  *
26  * 1 9/06/96 4:54p Walsh
27  *
28  */
29 package com.meitca.hsl.zonesjagents.skeleton;
30
31 import sun.tools.java.*;
32 import sun.tools.javac.*;
33 import java.io.*;
34 import java.util.*;
35
36 /**
37  * The Generator class generates an Method Invocation Skelton for an
38  * Agent. A Method Invocation Skelton allows the ConduitServer to
39  * dynamically invoke any method of an Agent. The Skeleton serves a
40  * similar purpose as does an RMI skeleton or an RPC server side stub.
41  * Before any Agent can travel, it is requires that a Skeleton be
42  * generated by it. A programmer can generate a skeleton by executing
43  * Generator with a command line like the following: <br>
44  * <pre>
45  * java com.meitca.hsl.zonesjagents.skeleton.Generator agentclassname
46  * </pre>
47  */

```

```

Generator.java_1      Tue Nov 12 07:45:33 1996      2

48  * The agentclassname paramter should be the fully qualified class
49  * name of the agent.
50  * @see ConduitServer
51  * @see Agent
52  * @see AgentSkeleton
53  * @author Thomas Walen
54  */
55 public class Generator {
56     /**
57      * the main method allows Generator to be called from the command
58      * line.
59      */
60     public static void main(String[] args) {
61         // Sanity check the command line arguments...
62         if (args.length < 1) {
63             System.err.println(StringResources.NO_AGENT);
64             System.err.println(StringResources.USAGE);
65             return;
66         }
67         if (args.length > 1) {
68             System.err.println(StringResources.TOO_MANY);
69             System.err.println(StringResources.USAGE);
70             return;
71         }
72
73         String agentClassName = args[0];
74         String packageName;
75         String shortClassName;
76
77         int lastSep = agentClassName.lastIndexOf('.');
78         if (lastSep != -1) {
79             packageName = agentClassName.substring(0, lastSep);
80             shortClassName = agentClassName.substring(lastSep + 1, agentClassName.length());
81         } else {
82             packageName = null;
83             shortClassName = agentClassName;
84         }
85
86         String skelFileName = shortClassName + "_Skel.java";
87
88         try {
89             String[] methods = findAgentMethods(agentClassName);
90             PrintStream out = new PrintStream(new FileOutputStream(skelFileName));
91
92
93
94

```

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```

Generator.java_1      Tue Nov 12 07:45:33 1996      3

95  generateSkel(agentClassName, packageName, shortClassName, methods, out);
96  compileSkel(skelFileName);
97  } catch (ClassNotFoundException) {
98      System.err.println(StringResources.NOT_FOUND + agentClassName);
99  } catch (IOException e2) {
100      System.err.println(StringResources.IO_ERROR + skelFileName);
101      System.err.println(e2.getMessage());
102      e2.printStackTrace();
103  }
104  }
105  }
106
107  static void generateSkel(String agentClassName,
108                          String packageName,
109                          String shortClassName,
110                          String[] methods,
111                          PrintStream stream) {
112
113      // Ok. This is going to be a fairly brute force approach
114      // First lets put a comment on the file
115      stream.println("//Skelton for " + agentClassName);
116      stream.println("//Generated by com.meitca.hsl.zonesagents.skeleton.Generator");
117
118      // The package statement
119      if (packageName != null)
120          stream.println("package " + packageName + ";");
121
122      stream.println("");
123
124      // Now some imports
125      stream.println("import java.lang.IllegalAccessException;");
126      stream.println("import com.meitca.hsl.zonesagents.shared.Agent;");
127      stream.println("import com.meitca.hsl.zonesagents.conduit.AgentSkeleton;");
128      stream.println("import " + agentClassName + ";");
129      stream.println("");
130
131      //now the class itself
132      stream.println("public final class " + shortClassName + "_Skel implements AgentSkeleton {");
133
134
135      // Define the static member variable containing the names of
136      // the objects methods
137      String methodsMember = "\tstatic public String methods[] = { ";
138      for (int i=0; i<methods.length; i++) {
139          if (i != 0) {
140              methodsMember = methodsMember + ", ";
141          }

```

4

```

142     }
143     methodsMember = methodsMember + "new String(\"\" + methods[i] + "\\");";
144 }
145 methodsMember = methodsMember + " ";
146 stream.println(methodsMember);
147 stream.println("");
148 
149 // now the invoke method
150 stream.println("\t\t\t\tpublic void invoke(Agent agent, int i) throws IllegalAccessException (" );
151 stream.println("\t\t\t\tswitch (i) {");
152 for (int i=0; i<methods.length; i++) {
153     stream.println("\t\t\t\t\tcase " + i + ":");
154     stream.println("\t\t\t\t\t{" + shortClassName + ")agent).\" + methods[i] + \"();\"");
155     stream.println("\t\t\t\t\t\t\t\t\t\tbreak;");
156 }
157 stream.println("\t\t\t\t\tdefault:");
158 stream.println("\t\t\t\t\t\t\t\t\t\tthrow new IllegalAccessException(\"Method \" + i + \" out of range.\");");
159 
160 // close the switch
161 stream.println("\t\t\t\t}");
162 
163 // close the invoke method
164 stream.println("\t\t");
165 stream.println("");
166 
167 // now the getMethods method
168 stream.println("\t\t\t\t\t\t\t\t\t\t\t\t\t\t\t\tgetMethods() {" );
169 stream.println("\t\t\t\t\t\t\t\t\t\t\t\t\t\t\t\treturn methods;");
170 // close the getMethods method
171 stream.println("\t\t\t\t\t\t\t\t\t\t\t\t\t\t\t\t}");
172 
173 // close the class definition
174 stream.println("}");
175 
176 static String[] findAgentMethods(String agentClassName) throws ClassNotFoundException {
177     ClassDeclaration classDecl = new ClassDeclaration(Identifier.lookup(agentClassName));
178     BatchEnvironment env = new BatchEnvironment(new ClassPath(System.getProperty("-java.class.path")
179 ));
180 
181     ClassDefinition classDef = classDecl.getClassDefinition(env);
182     Vector agentMethods = new Vector();
183 
184     FieldDefinition fieldDef = classDef.getFirstField();
185 while (fieldDef != null) {
186     if (fieldDef.isMethod()) && !fieldDef.isConstructor() && fieldDef.isPublic() {
187         Type argTypes[] = fieldDef.getType().getArgumentTypes();

```

```

Generator.java_1      Tue Nov 12 07:45:33 1996      5

188         if (argTypes.length == 0) {
189             if (fieldDef.getType().getReturnType() == Type.tVoid) {
190                 agentMethods.addElement(fieldDef.getName().toString());
191             }
192         }
193         fieldDef = fieldDef.getNextField();
194     }
195     //turn it into an array
196     String[] array = new String[agentMethods.size()];
197     for (int i=0; i<agentMethods.size(); i++) {
198         array[i] = (String)agentMethods.elementAt(i);
199     }
200     return array;
201 }
202
203
204
205 static void compileSkel(String skelFileName) {
206     Main compiler = new Main(System.out, "javac");
207     String[] params = new String[1];
208     params[0] = skelFileName;
209     if (!compiler.compile(params)) {
210         System.err.println("StringResources.COMPILE_ERROR + skelFileName");
211     }
212 }
213
214 }

```



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```

StringResources.java_1      Tue Nov 12 07:45:33 1996      1      11/11/96 5:16p Billp $
1  /* $Header: /ccm/meitca/hsl/zonesjagents/skeleton/StringResources.java 3
2  *
3  * Copyright 1996 Horizon Systems Laboratory,
4  * Mitsubishi Electric Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * The String Resources for the skeleton package
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/skeleton/StringResources.java $
13 *
14 * 3 11/11/96 5:16p Billp
15 * Made correction to company name
16 *
17 * 2 9/12/96 11:00a Walsh
18 * Automatically compile the skeleton file
19 *
20 * 1 9/06/96 4:54p Walsh
21 *
22 */
23 package com.meitca.hsl.zonesjagents.skeleton;
24
25 class StringResources {
26
27     // Generator.java
28     public static String USAGE = "Usage: generator agentclassname";
29     public static String NO_AGENT = "generator: You must specify an agent class name.";
30     public static String TOO_MANY = "generator: Too many parameters specified.";
31     public static String NOT_FOUND = "generator: Agent class not found -- ";
32     public static String IO_ERROR = "generator: IO error while attempting to write the skeleton file -- ";
33     public static String COMPILE_ERROR = "generator: Anb error while attempting to compile the skeleton file ---";
34 }

```

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Mitsubishi Electric ITA

**Patent Disclosure for  
Dynamic Synchronous Collaboration  
Framework for Mobile Agents**

*November 12, 1996*

*Horizon Systems Laboratory  
Mitsubishi Electric ITA  
1432 Main Street  
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## Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents

### 1. Introduction

This document serves as a patent disclosure on the invention entitled *Dynamic Synchronous Collaboration Framework for Mobile Agents*. This document includes a discussion of: prior art, problems with prior art, details of the invention, and improvements of this invention over prior art.

### 2. Prior Art

"Agent" is one of the most overused terms in the software industry today. Although the term may be used in a wide variety of contexts, software Agents can be classified into two major categories: Intelligent Agents and Mobile Agents. Although the two differ in scope and capabilities, both types of Agents are able to perform work asynchronously and autonomously on behalf of their owners. Intelligent Agents are endowed with some degree of reasoning and learned behavior and may make decisions on behalf of their owners. These Agents are generally stationary and execute on a single system. Mobile Agents, on the other hand, may be transported across nodes in a network, performing computations as they migrate.

The original concept for Agents stems from the Artificial Intelligence community. The behavior of Intelligent Agents may be determined by programming or by decisions made by the Agents on behalf of their owners. As an example, an Intelligent Agent may search a database for unusual outdoor scenery, making its own decisions as to whether or not each scene meets the specified criteria.

Intelligent Agents generally employ both synchronous and asynchronous modes of communication. Agent communication may take the form of queries or collaborative computations. In the realm of Agent computing collaboration may be defined as "the coordination of the computations of multiple Agents to achieve a desired result" (e.g., to solve a complex problem). Collaboration often results from discovery (i.e. the need to

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**Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents**

collaborate with a specific Agent regarding a certain subject is not known a priori, but is, rather, determined as a result of the Agent's computations.)

Both the interaction between these Agents and the context in which they execute must be formally specified. Standardization has not yet been achieved for these objectives. However, the prevalent means for accomplishing these results is via implementing a user model and specifying queries and assertions by using a knowledge representation language, the most popular of which is currently Knowledge Query Manipulation Language (KQML), and by developing Ontologies, or vocabularies of common terms to be utilized by interacting Agents. KQML is comprised of both a language, with a syntax unlike procedural or object-oriented languages, and a communications protocol. An Ontology is defined as "an explicit specification of a conceptualization". The syntax and semantics of an Ontology are generally extensions of a first-order predicate calculus, typically the Knowledge Interface Format (KIF).

The combination of KQML, KIF, and Ontology development is a complex task. Some implementations utilizing these mechanisms are being developed in the Artificial Intelligence community. But this approach has not caught on in other software applications.

In contrast to Intelligent Agents, Mobile Agents are usually explicitly programmed to accomplish a specific task. As an example, a Mobile Agent could migrate to travel agencies on the World Wide Web and determine the lowest cost air fare between two cities. In this case, there is no need for learned behavior or complex reasoning.

However, the amount of information accessible on distributed systems, including databases, the Internet and Intranets, is growing at a staggering pace and much of it is available in incompatible storage formats. The need to filter information and make decisions based on its content is increasing, and with it, the need for increased collaboration among Mobile Agents.

The need for collaboration is illustrated by extending the above travel agency example. A Mobile Agent may need to clone itself and instruct each of its counterparts to migrate to a different travel agency site to obtain the best package for a trip to one or more ski resorts meeting certain parameters, including air fare, lodging, meals, lift tickets, and car rental. Furthermore, the information may, itself, be stored in different formats (databases, etc.), necessitating some amount of filtering and data reformatting. Once the Agents have obtained their information, they need to collaborate with each other to correlate their results and determine the best package available at each resort for different travel dates and the overall best deal.

Mobile Agents are evolving to include increased intelligence and collaboration. Some research organizations have begun incorporating KQML and Ontologies into Mobile

**Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents**

Agent implementations, while other utilize different knowledge representation languages to implement Agent communication. Still, others use proprietary object languages.

**3. Problems with Prior Art**

The KQML/Ontology mechanism and other knowledge representation languages are ill-suited for general-purpose software applications. They require programmers to learn multiple languages to formally specify communications and to develop complex dictionaries of terms – a task that is currently ill-defined. The knowledge representation languages are also extremely unlike the procedural and object-oriented languages utilized in building business and general-purpose software applications.

The need to support asynchronous collaboration adds significant complexity to Agent systems implemented via knowledge representation languages (e.g. KQML) and Ontologies. Furthermore, there exists a class of Mobile Agents which solely require synchronous collaboration, e.g., the travel agency application described above. This type of Agent application essentially subdivides a larger task into smaller pieces and creates Agents to migrate throughout the network to accomplish it. For these Agents, there is no benefit in the added complexity of coding in multiple languages and developing Ontologies, nor in the support for asynchronous communication. A synchronous collaboration framework in the Agent's language is the best means for these Agents to coordinate their results and implement adaptive behavior.

**4. Some Details of the Invention**

The dynamic synchronous collaboration framework utilizes a distributed synchronization point plus object-oriented abstractions to provide synchronous collaboration for Mobile Agents in a distributed system. The framework simplifies collaboration for applications which subdivide a complex problem into several pieces and farm out the work to multiple Mobile Agents.

This framework enables Mobile Agents within an application to perform synchronous collaboration with one or more affiliated Agents in the application's native language. This is accomplished via the *Agent Group* abstraction. Agents wishing to collaborate with each other must belong to one (or more) of the same Agent Groups. The fundamental principle behind Agent Group collaboration is that Mobile Agents performing sub-computations, possibly on different nodes in a distributed system, will need to periodically correlate their results, and potentially adapt their behavior based on the results of the correlation. The Agent Group acts as a distributed synchronization point for this type of synchronous collaboration.

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**Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents**

The dynamic nature of the Agent Group enables Agents to join and leave the group at will. Hence no a priori knowledge of the actual Agents comprising a group is required and group membership may change over time.

A distributed name space maintains a reference to each Agent Group. Hence, Agent Groups may be located via their entry the name space. When an Agent Group is created, it is automatically added to the name space.

The Agent Group's primary responsibility is to facilitate synchronous collaboration for Mobile Agents. However, it also serves as a central point for distributing asynchronous events to Agents in the group. A typical event may be the termination of a particular Agent. As a side effect, the Agent Group also tracks the travels of its constituent Agents throughout the network.

The travel agency example illustrates the function of Agent Groups. The problem to be solved can be stated as follows: A user wishes to determine the best package for a trip to a ski resort. The Agents must determine the best travel date and time (e.g. any week in February starting on a Saturday, and flying before noon) and lodging must meet certain criteria (e.g., a two-bedroom condominium). The trip includes all expenses (e.g., air fare, lodging, meals, transportation, and lift tickets). The user may also specify several possible travel destinations.

This application is composed of multiple Agents -- each is responsible for querying one or more data sources (in perhaps different formats) for specific information (e.g., searching a particular travel agency's database of promotional trips to determine if any meet the criteria specified by the user.) Some Agents may query legacy database systems, whereas others may search ODBC compliant databases. (The actual mechanisms for handling different data sources is beyond the scope of this invention.)

Before the Agents are transported throughout the network they join a new Agent Group. The Agent Group tracks its Agents' travels throughout the network. At any point, an Agent may be in one of several states. Figure 1 depicts three Agents in an Agent Group performing computations and one Agent in-transit between nodes.

At different points during their migration, Agents may wish to correlate their results, and potentially change their migration plans or behavior. Suppose each Agent migrates to a local travel agency. Before migrating to travel agencies in different cities, the Agents may wish to correlate their results and potentially adjust their behavior. Suppose one of the Agents determines that a particular ski resort, say Taos, has no two-bedroom condominiums available during February. The Agents in the group may wish to drop all further queries about trips to Taos.

Agent Group collaboration is implemented via a distributed synchronization point (also known as a collaboration point) and a software routine to analyze the results of each

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**Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents**

**Agent's computation.** The Agent Group abstraction provides the distributed synchronization point. Each application need only provide its own software method to analyze the results and potentially allow each Agent to adapt its behavior.

The distributed synchronization scheme requires that each Agent arrive at the collaboration point before collaboration may commence. Hence, it is best suited to applications that subdivide a complex problem into many sub-tasks that need to correlate their results. As each Agent arrives at the collaboration point, it posts the results of its computations to the Agent Group, and blocks until all the other Agents in the group arrive. Figure 2 depicts one Agent in the group waiting to collaborate while three others are still performing computations.

The Agent Group collects the results of each Agent's sub-computation. When all Agents have arrived at the collaboration point, as shown in Figure 3, the Agent Group notifies them that collaboration may commence. When it unblocks the waiting Agents, the Agent Group passes the collected results to each Agent. Each Agent then calls the application-specific method to analyze the results and potentially adapt its behavior. Figure 4 shows that all Agents have arrived at the collaboration point and are now in the analysis stage.

The synchronous collaboration framework supports both parallel and serialized collaboration analysis. Figure 4 depicts a parallel analysis implementation; Figure 5 illustrates a serialized collaboration analysis, in which one Agent is in the Analysis state, while the rest remain waiting in the Collaborate state.

The distributed collaboration point may be implemented via an object transport or by an RPC mechanism. It may also be implemented in any procedural or object-oriented language. Object-oriented languages simplify the implementation, as the application need only subclass the Agent Group abstraction and provide a concrete method to analyze the results and potentially adapt the Agent's future behavior.

The Agent Group ensures that all Agents in the group arrive at the synchronization point by tracking the Agent's migration through the network. In the current implementation, as part of a mobile Agent system, a server (known as the Conduit Server) on each node manages the Agent's migration and informs each of its Agent Groups when the Agent arrives and departs. Should an Agent fail to arrive at a collaboration point in a pre-determined, configurable length of time, the Agent Group will "ping" the Agent by sending a message to ensure that it is still alive, as shown in Figure 6. (In the current implementation, this is performed via the Conduit Server on the node where the Agent is executing.) If the Agent fails to respond to the ping, the Agent Group notifies the other members of the group by distributing a Collaboration Failed asynchronous event to them that indicates that a particular Agent is not responding. The Agents may then indicate whether or not they wish to proceed with the collaboration. Figure 7 depicts the Agent Group's distribution of a Collaboration Failed event followed by the remaining Agents

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**Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents**

indicating that they wish to continue the collaboration. Alternatively, the Agents could decide to abort the collaboration.

The Agent Group also implements deadlock detection by means of the time-out mechanism and Agent ping described above. The ping actually returns the state of the Agent in question (via the Conduit Server). If the Agent is already in the Collaborate state but has not arrived at this collaboration point, a deadlock has occurred. This is shown in Figure 8. In this case, the Agent Group will abort the collaboration and notify the Agents in the group of the deadlock by sending them a Deadlock Event, as shown in Figure 9. Note that since Agent Group collaboration is designed for closely coordinated Agents, the existence of a deadlock is generally a result of a programming error. Hence, the Agent Group does not need to employ a more sophisticated scheme for deadlock detection or avoidance.

Agent Groups provide reliability by saving the state of each Agent in the group to persistent storage. If the Agent Group should terminate unexpectedly, it is restarted and reads the state of the group members from persistent storage. The Agent Group's restart is transparent to the Agents. They actually communicate with an Agent Group Proxy (instead of an Agent Group), which shields them from Agent Group failures.

Figure 11 illustrates the flow of a typical collaborating Mobile Agent. Each Agent creates an Agent Group Proxy for each Agent group it wishes to join. The proxy's primary responsibility is to maintain an active connection to its associated Agent Group and to re-establish the connection or re-create the Agent Group, as needed, during Agent Group failures.

When the Agent Group Proxy is initialized, it establishes a connection with the appropriate Agent Group. It first attempts to find a reference to it in the name space. If this fails, it creates the Agent Group and enters a reference to it into the name space. The algorithm guarantees the atomicity of this operation.

After the proxy has created the Agent Group or established a connection to it, the Agent continues its computations and migrations. Eventually, it may attempt to collaborate its results. This is accomplished by means of the Agent Group Proxy. If the Agent Group has failed or is in a unknown state, the proxy will be unable to contact it. If this occurs, the Agent Group Proxy retries the communication. If, at this point, the proxy is still unable to communicate with the Agent Group, it recreates it and updates the name space with a reference to the new Agent Group. The re-creation of the Agent Group is serialized to prevent multiple Agent Group Proxies from simultaneously doing so. If a proxy determines that the Agent Group is in the process of being re-created, it simply waits until it can find a reference to the new group in the name space. Once the Agent Group has been re-created, the proxy retries the collaboration.



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**Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents**

As mentioned earlier, Agent Groups provide a distributed events mechanism in addition to the synchronous collaboration framework. The distributed events mechanism enables the Agent Group to notify members of the group of outstanding events, such as the termination of an Agent, or the detection of a collaboration deadlock. Agents may build on this mechanism to forward application-generated events to other members in the group. Hence, if an Agent catches an application-generated exception it may notify the other Agents in the group before terminating. Figure 10 illustrates how the Agent Group forwards an Exception Event, generated by one of its Agents, to the rest of the group.

Currently, the Agent Group handles distributed events by maintaining a (possibly remote) reference to an event queue associated with each Agent. The Agent Group forwards all events it receives to the other members of the group by enqueueing it. The Agent Group may be implemented without a remote referencing capability, but this would add significant complexity. In the current implementation, each Agent contains an events thread which is responsible for dequeuing the event and calling the application-specific event handler. (This thread could easily be a process, if threads were not available.)

In addition to forwarding events to members of the group, the Agent Group may generate its own events and distribute those to the group members. As an example, the Agent Group distributes a Deadlock Event to the group members when it detects a deadlock situation, as illustrated in Figure 9.

As mentioned earlier, Agent Groups track the migrations of their constituent Agents, with help from the Conduit Server (in the current implementation). If an Agent is in transit when the Agent Group is forwarding events, it queues the events locally, as shown in Figure 10. Once the Agent arrives at its destination, it notifies the Agent Group, via the Conduit Server. The Agent Group then flushes the events it stored locally for that Agent.

Agent Groups implement varying levels of persistence, as defined by the actual configuration. Memberships and Agent states are updated infrequently, so they are generally written to persistent storage. However, local queues maintained on behalf of in-transit Agents may also be saved in persistent storage, if desired.

Implementation of the Agent Group in an object-oriented language enables applications to extend its functionality, if required, by subclassing the Agent Group object.

**5. Benefits of the Invention**

The work described above provides several benefits. It greatly simplifies the implementation of synchronous collaborating Mobile Agents, especially for applications that subdivide a complex task into a series of related sub-tasks. There is no need for application developers to learn knowledge query representation languages, such as KQML, or to develop complex Ontologies. The dynamic synchronous collaboration framework provides a natural programmatic implementation that may be programmed in a

Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents

number of languages. An added benefit of this scheme is that collaboration is implemented as part of the application, programmed in the same language as the rest of the application. The current implementation in an object-oriented language (Java) also enables the technology to be easily extended so that more complex intelligence schemes may be supported.

Agent Groups facilitate Mobile Agent tracking and may also be queried by tools that monitor Agents. In addition, collaboration may be performed through discovery, as with many knowledge representation languages.

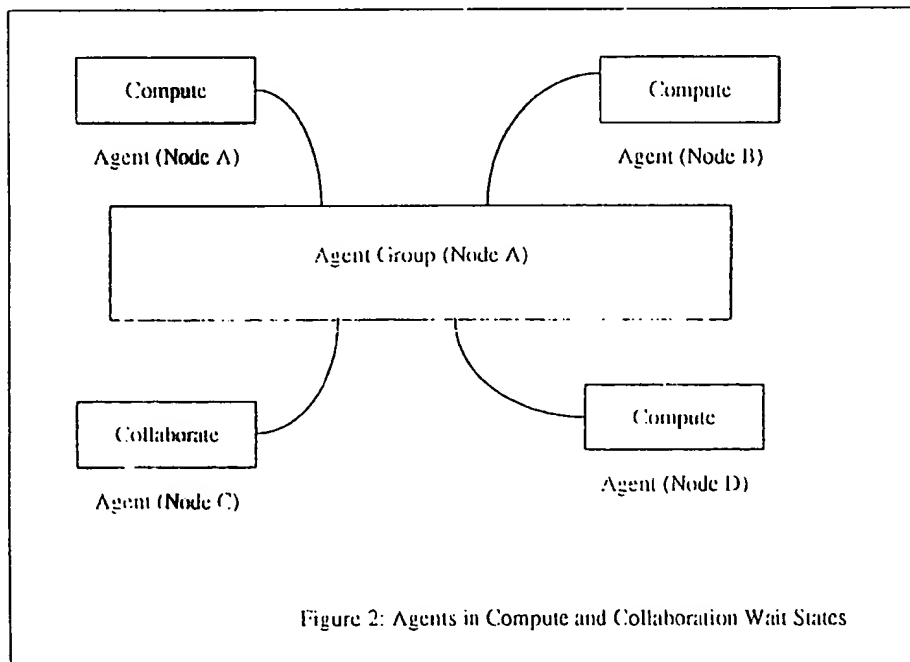
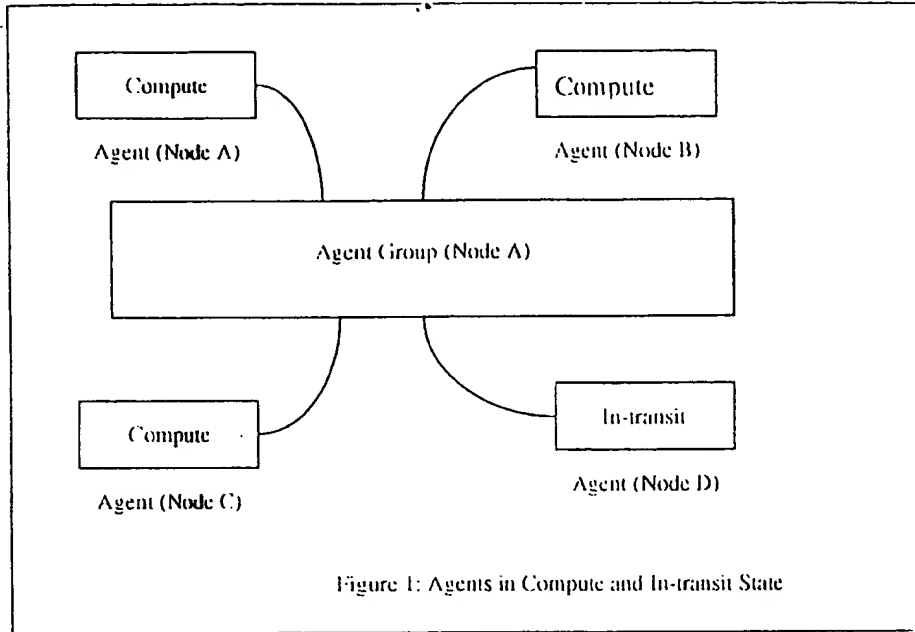
Agent Groups also offer reliability by providing persistent Agent Group membership and Agent state information. Furthermore, Agent Group Proxies shield Agents from the effects of Agent Group failures. They detect an Agent Group's failure and automatically restart the failed Agent Group (which then restores the state of its membership from persistent storage) and retry the current operation (e.g., collaboration). The algorithm also guarantees the atomicity of Agent Group creation and re-creation.

An Agent Group also detects Agent failures and deadlocks and forwards this information to the other members of the group via its distributed events mechanism. Furthermore, this mechanism allows Mobile Agents to asynchronously notify associated Agents of relevant events, such as the catching of an exception.

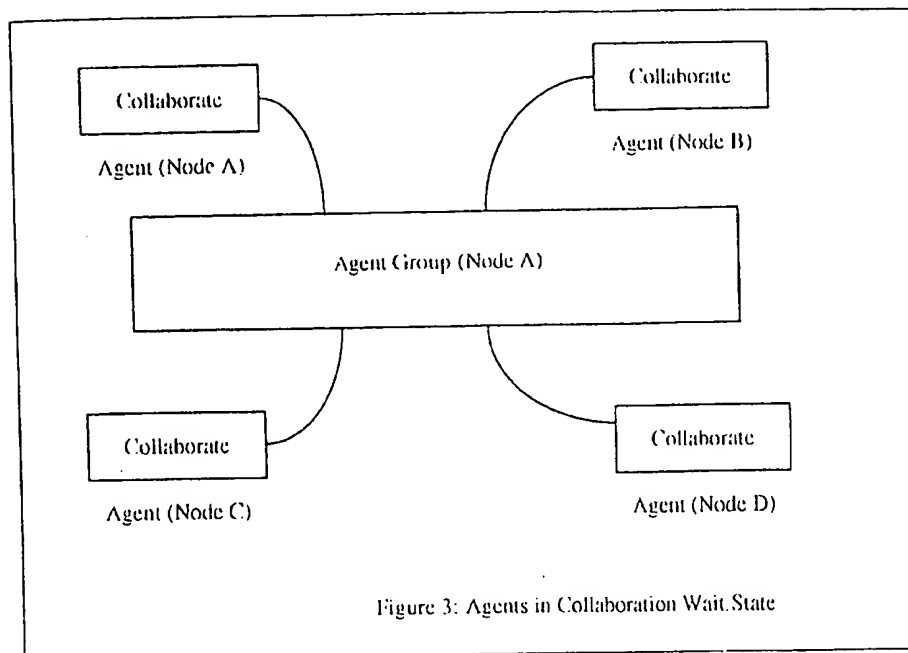
Implementation of Agent Groups in an object-oriented language also enables additional application-specific functionality to be easily added via inheritance and polymorphism.

## Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents

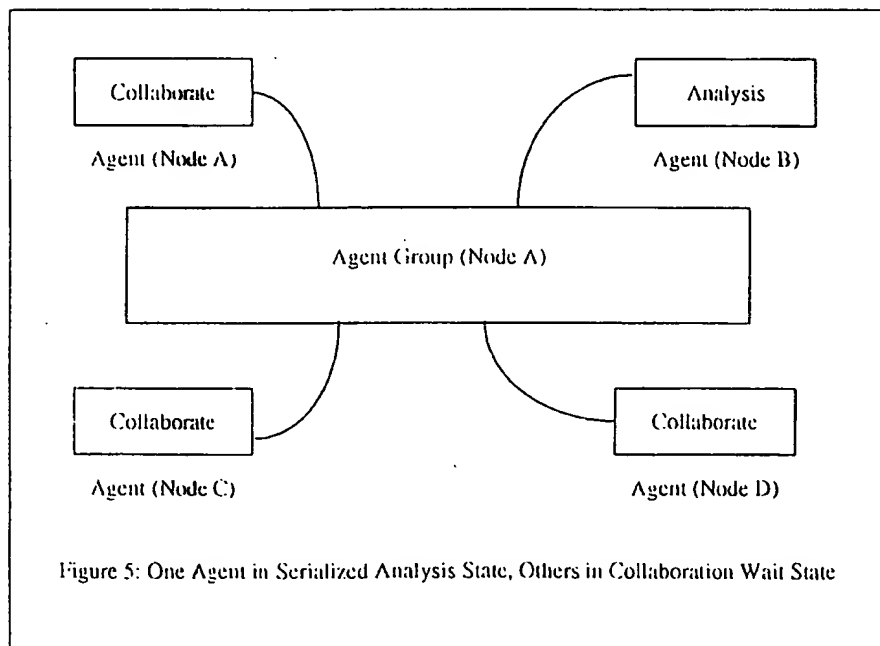
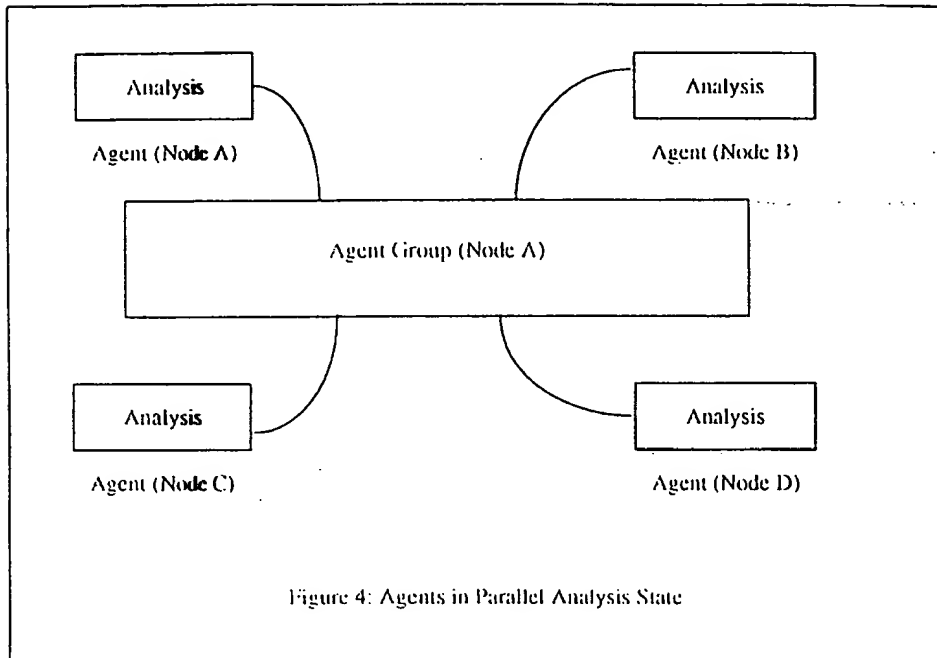
## 6. Figures



## Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents

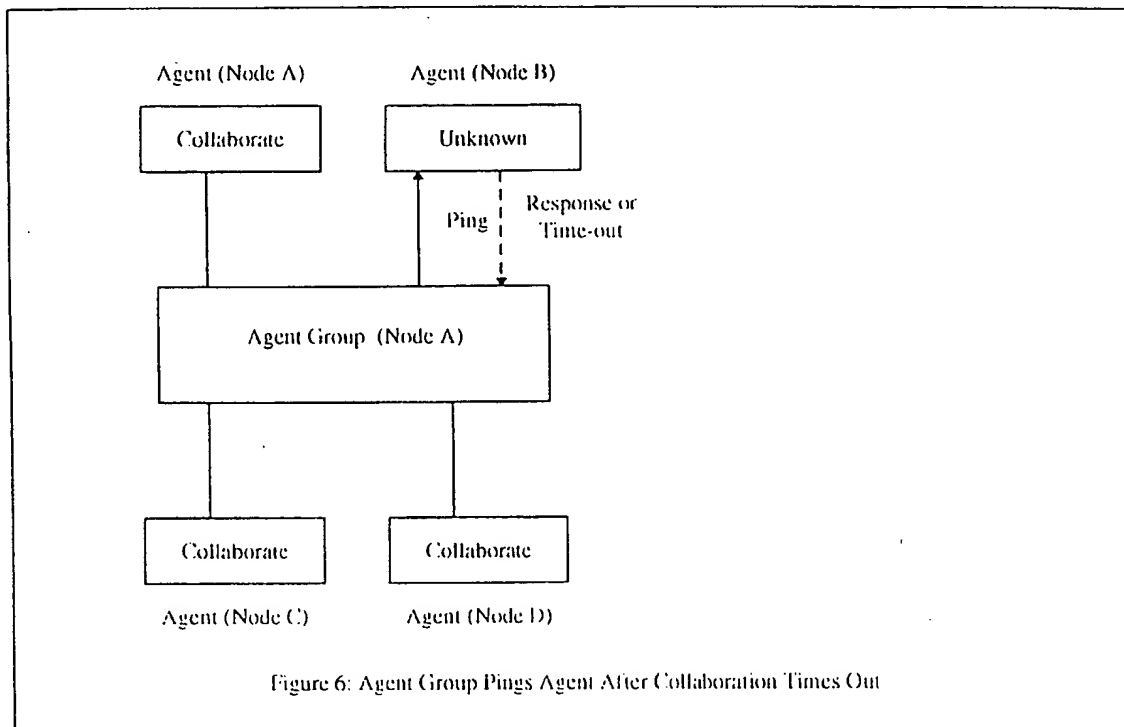


## Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents



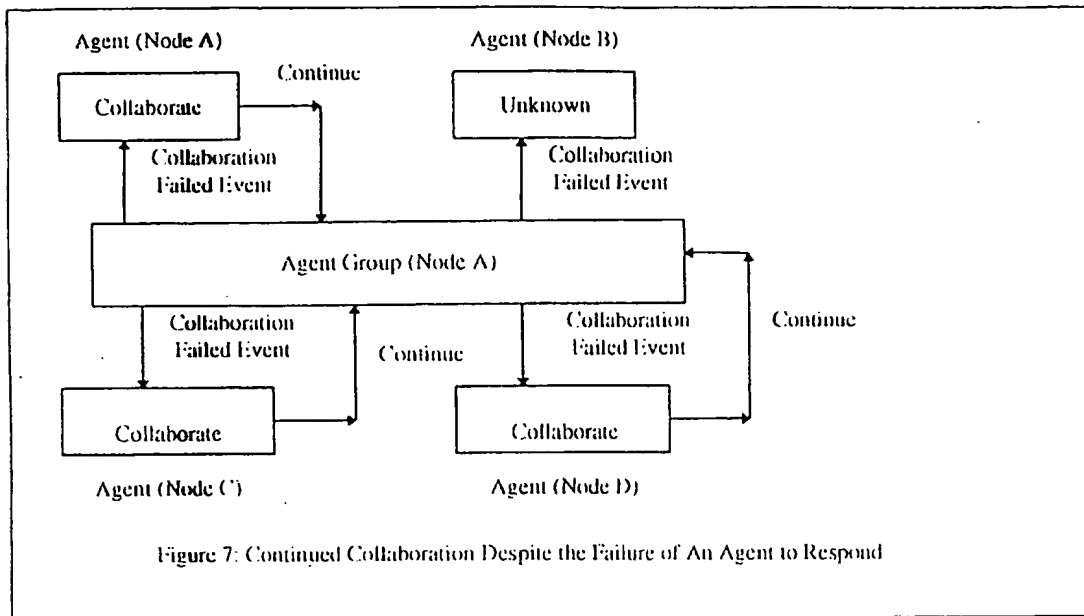
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## Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents



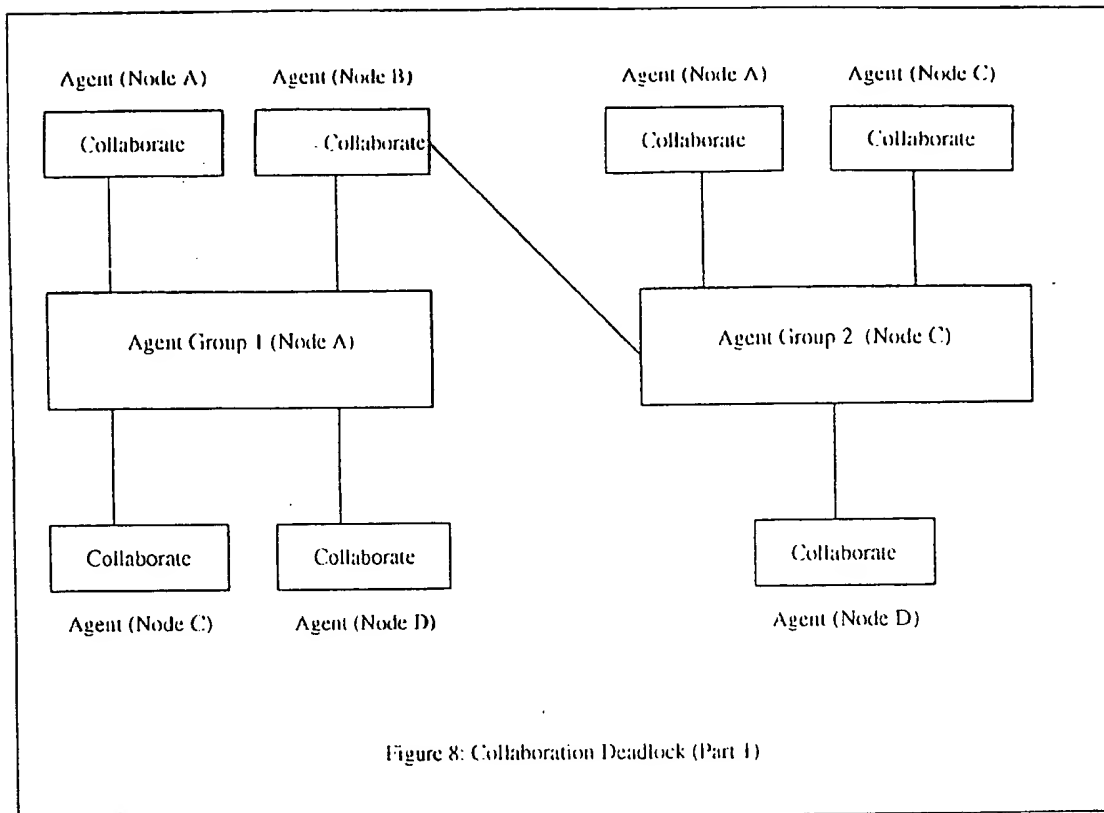
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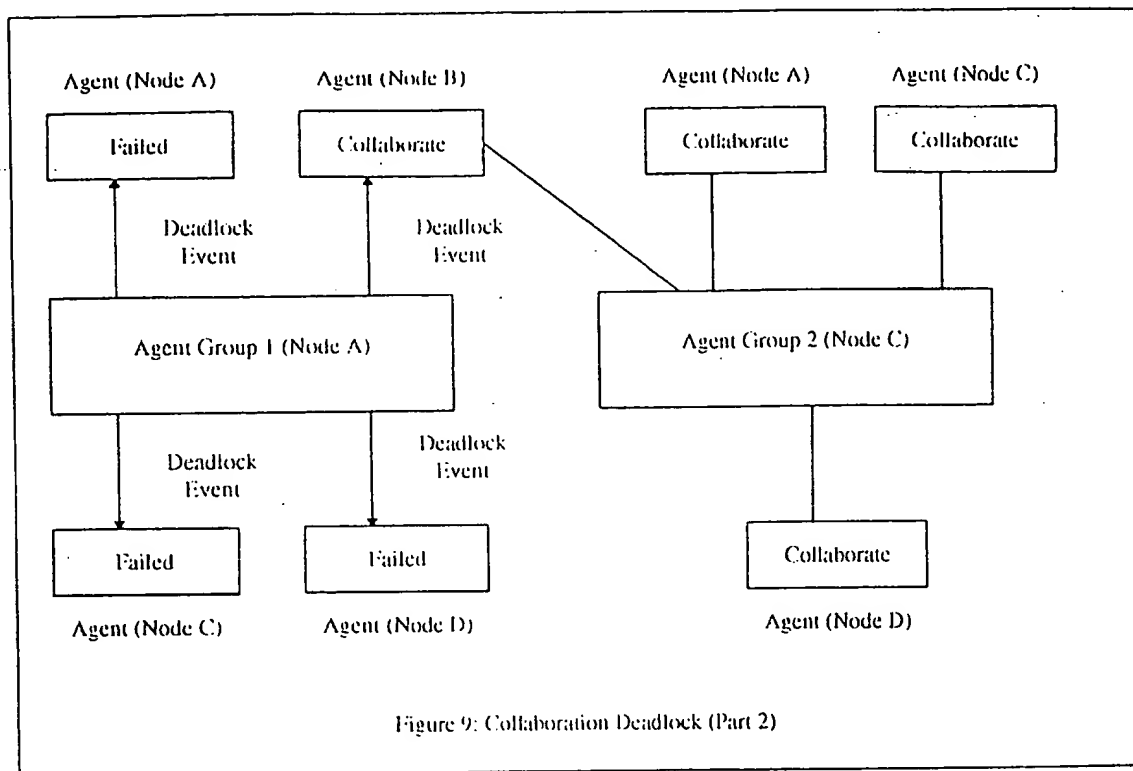
Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents





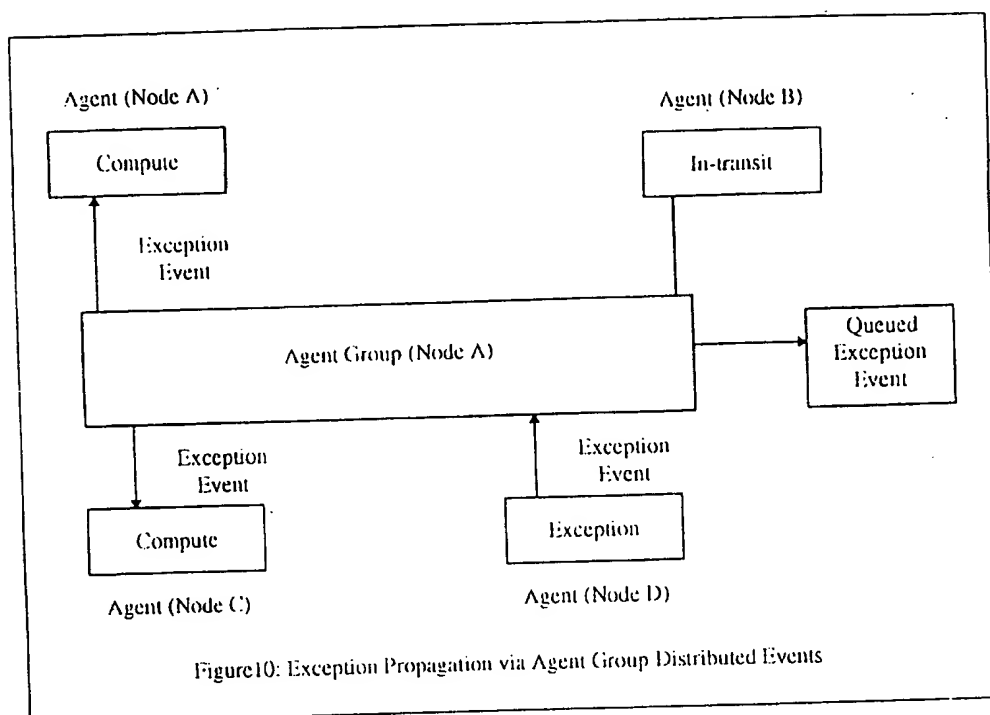
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## Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents



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## Patent Disclosure for Dynamic Synchronous Collaboration Framework for Mobile Agents

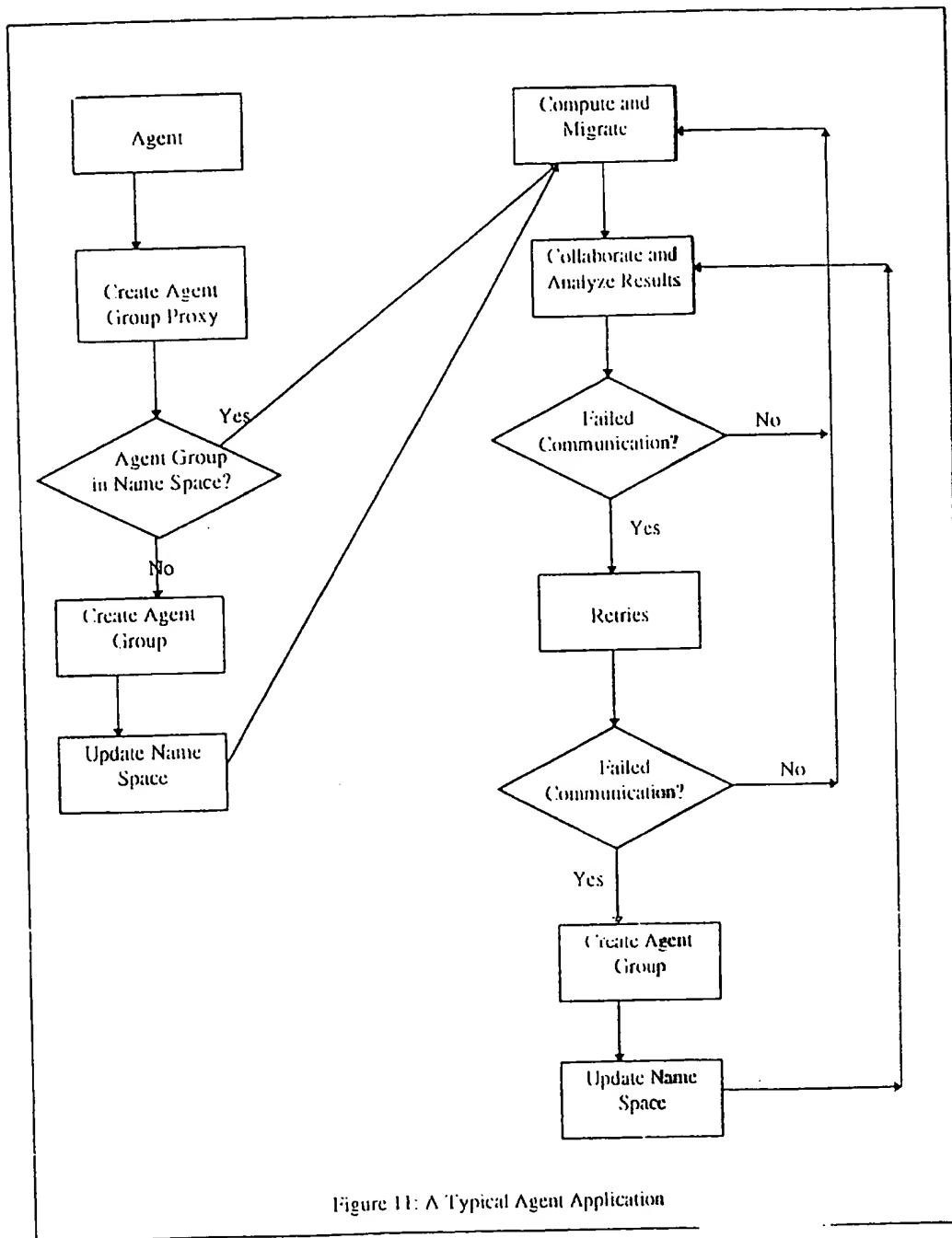


Figure 11: A Typical Agent Application

# Mitsubishi Electric ITA

## Design Specification for Java Agent Coordination

*Version 0.2*  
*November 12, 1996*

*Horizon Systems Laboratory*  
*Mitsubishi Electric ITA*  
*1432 Main Street*  
*Waltham, MA 02154*

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# Design Specification for Java Agent Coordination

*Version 0.2<sup>1</sup>*

## 1. Introduction

Java agents have the capability of coordinating their activities. This coordination takes two main forms: synchronized collaboration and asynchronous notifications. These modes of communication complement each other and their implementations are related.

### Collaboration

The collaboration paradigm is implemented as follows:

- multiple agents perform computations at different nodes in the network;
- after performing all or a subset of their operations, agents wait at a distributed synchronization point until all agents have "arrived";
- agents coordinate by potentially serialized execution of a synchronized method.

Coordination can take the form of performing computations on intermediate results and/or updating agent itineraries.

### Notification

The notification scheme uses a distributed events mechanism to communicate agent state changes that occur asynchronously. It is mainly utilized for distributed exception handling, but may also be used to notify related agents of events, such as another's termination.

As described above, agent coordination utilizes distributed synchronization and event handling. However, Java possesses neither of these. Actually, its synchronization primitives are limited to: critical sections on a single system and a notification scheme that can only handle a single type of event. Hence, a great deal of the complexity in the task of agent coordination is comprised of implementing mechanisms to overcome Java's unsuitability for distributed processing. These mechanisms are described in the remainder of this document, along with the new objects that implement them

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<sup>1</sup> Revision History:

07/26/96 Version 0.1 Initial revision.

11/12/96 Version 0.2 Major changes to Notifications and Exceptions and Collaboration sections to reflect actual implementation. Removed Events section.

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**2. Synchronization**

As mentioned above, agent coordination requires distributed synchronization mechanisms, such as locks and events. Since Java does not provide any distributed locking, we are faced with the following choice:

1. Utilize a centralized locking scheme.
2. Develop our own distributed locking paradigms.
3. Use Java's native methods to interface with the operating system's synchronization primitives.

The latter choice is unacceptable because it compromises the portability of our agent infrastructure, whereas the first option may potentially introduce considerable network overhead. The second alternative also requires significant development effort even to implement a well-known solution to the problem.

In the interest of expediency (as required by the tightness of our schedule), the initial Java agent infrastructure utilizes RMI to implement a centralized locking scheme. Locking is implemented via method invocations on a potentially remote object (called an *AgentGroup*. See Section 3 for details.) Agent coordination is implemented by (remote) invocations on a method which requires synchronized access. (See Section 3.)

**3. CollaboratorAgent and AgentGroup**

Agents that may wish to collaborate their results subclass *CollaboratorAgent*, an abstract class derived from *Agent*. *CollaboratorAgent* contains a minimum of two threads – one to perform computation and to travel and another to handle asynchronous event notifications. Applications that contain collaborating agents subclass *CollaboratorAgent* and, of course, these derived classes may implement several computation threads.

Each collaborating agent belongs to one or more agent groups, which are described by *AgentGroup* objects. *AgentGroup* is actually a distributed RMI object. *AgentGroup* defines the interface; *AgentGroupImpl*, an abstract base class derived from *PersistentEventGroupImpl*, provides the implementation. (See *Design Specification for Distributed Java Events* for a description of *PersistentEventGroupImpl*.)

An *AgentGroup* is essentially a unit of coordination. Hence agents may coordinate with all the other agents in an *AgentGroup*. They may also create new *AgentGroups* on demand, and join and leave groups at will. (In practice, *AgentGroup* must be subclassed to implement agent collaboration. However, this document does not distinguish between the base class and its derived classes and refers to them collectively as *AgentGroups*.)

An *AgentGroup* is an object that is essentially shared among the members of an agent coordination group. It is owned by the *Agent* that initially creates the group (an agent group is created by instantiating *AgentGroup*) and accessed via a potentially remote RMI reference.

The relationship between *CollaboratorAgent* and *AgentGroup* is similar to that of *Thread* and *ThreadGroup*: A *ThreadGroup* maintains references to the *Threads* composing the group; an *AgentGroup* maintains a similar list of its *CollaboratorAgents*. Both *ThreadGroups* and *AgentGroups* form a hierarchy and each contains a reference to its parent group. *Thread*'s constructors are either passed a reference to a *ThreadGroup* or they save a

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reference to the parent's Thread's group. Likewise, CollaboratorAgent's constructors may be passed one or more AgentGroups or save a reference to AgentGroup of its parent, if it exists.

However, there is one noticeable difference between the two types of groups. A Thread may only belong to one ThreadGroup at a time, whereas a CollaboratorAgent may simultaneously be a member of several AgentGroups, which constitute a hierarchy. Hence, Threads contain a reference to their associated ThreadGroup, but CollaboratorAgents maintain a list of references to their AgentGroups.

Support for multiple AgentGroups facilitates coordination among related groups of agents and also enables the creation of an AgentGroup hierarchy through which communication may be propagated. The pilot application may utilize multiple agent groups, as shown in Figure 1.

This figure portrays an example of two AgentGroups: AgentGroup A consists of three agents – one on each LAN in the system, whereas AgentGroup B contains agents on multiple nodes on LAN 3. A distributed application running on a configuration such as this typically creates multiple AgentGroups when it needs to traverse the WAN. In this case, 3 agents are created in AgentGroup A, one for each LAN. Once they arrive on a node, these agents clone themselves, creating more agents to be distributed across nodes on the LAN (e.g., AgentGroup B). This approach minimizes network traffic over the WAN and forms a multi-level hierarchy of AgentGroups. Agents in the intra-LAN groups (e.g., AgentGroup B) can communicate their results, which can then be coordinated with the inter-LAN group (i.e., AgentGroup A).

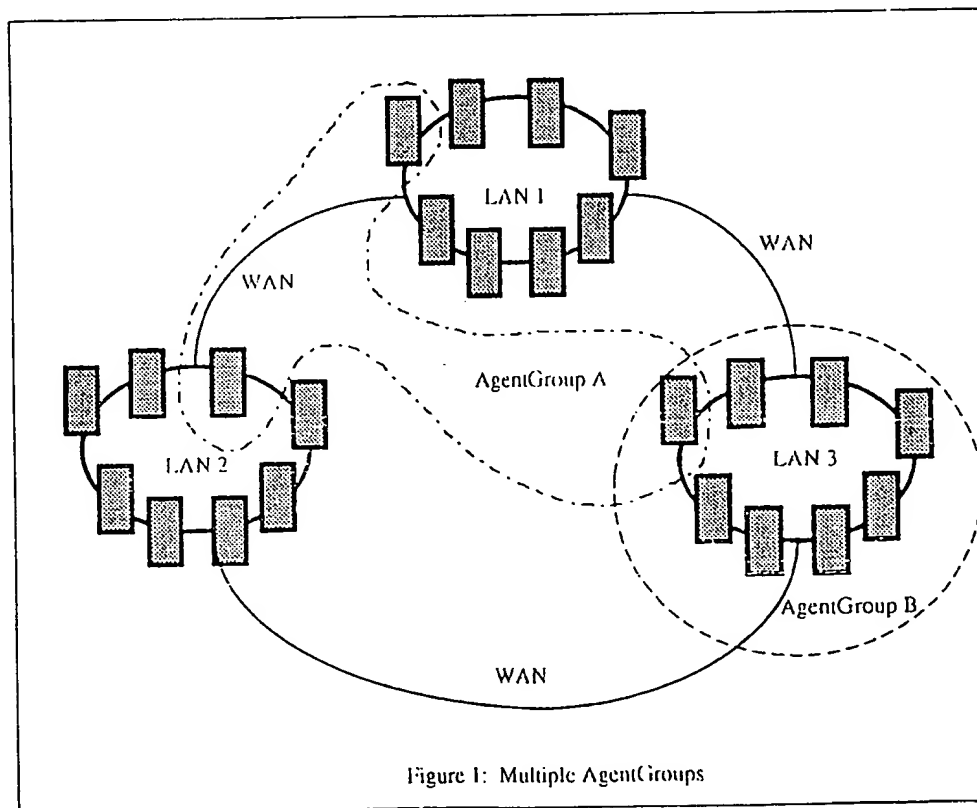


Figure 1: Multiple AgentGroups

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By default, RMI passes all local objects by copy. However, the above scheme requires that each Agent actually maintain (remote) references to its AgentGroups. Hence, the agent infrastructure overrides some of RMI's object serialization methods to generate the required references.

#### 4. Notifications and Exceptions

Both asynchronous notification and collaboration are implemented via the associated AgentGroup object. The following description serves as an example of asynchronous notification handling via distributed events. (See *Design Specification for Distributed Java Events* for more details on event handling.)

1. An agent catches an exception and wishes to notify the other members of the group.
2. The agent posts an *AgentExceptionEvent* to the AgentGroup via the group's *postEvent* method. The *AgentExceptionEvent* indicates the type of exception that occurred.
3. The AgentGroup posts the *AgentExceptionEvent* to the other agents in the group.
4. Each agent's Event Handler performs application-specific handling of the *ExceptionEvent*.

If the agent that caught the exception wishes to notify another associated Agent Group, it repeats the above procedure with the next AgentGroup object.

Occasionally, the Agent Group may generate events that it directly forwards to a member of the group (e.g., to "ping" it after it fails to arrive at a collaboration point) or others that it "multicasts" to its members (e.g., an Agent's failure to reply to a ping).

#### 5. Collaboration

Agent collaboration is more complicated than asynchronous notifications. It is implemented as follows:

1. An agent performs some computation and arrives at a synchronization point.
2. The agent performs a (remote) invocation of the AgentGroup's *collaborate* method, passing it an *AgentStatus* object.
3. If no collaboration is in-progress (i.e., this is the first agent that has requested collaboration), *collaborate* calls its synchronized *beginCollaborate* method, which initializes the number of agents to wait for before collaboration may begin (i.e.,  $n-1$  for an  $n$ -agent group.) (Race conditions are handled by checking if the agent count has been initialized (i.e., it is non-zero) before continuing. A race implies that two agents are attempting to initiate the same collaboration. Otherwise the application is semantically incorrect.) This routine saves the requesting agent's unique ID (obtained from the *AgentStatus* object) and starts a collaboration timer (with sufficient time for agents to arrive across the WAN) by passing a configurable time-out value to the AgentGroup's *wait* method.
4. Otherwise (i.e., if a collaboration is in-progress), *collaborate* calls the synchronized *decrementCollaborate* method to add the requesting agent's unique ID to the list of



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agents arriving at the collaboration point and to decrement the waiting agent counter. If the counter is non-zero, this method blocks with no time-out value. Otherwise, the Agent Group awakens the other threads waiting for collaboration to commence.

5. If the timer expires, all agents did not arrive at the collaboration point in time. This may occur because an agent received an uncaught exception and terminated unexpectedly or because a deadlock condition exists. (Since agents may belong to multiple groups, overlapping collaborations could result in deadlock. However, a properly coded application will not generate deadlocks because the collaboration points must be known a priori and must be executed in the same order among collaborating agents, i.e., collaboration must first be handled at the leaf Agent Group and propagated up the hierarchy.) If a time-out occurs, the Agent Group thread initiating the collaboration (on behalf of its associated CollaboratorAgent) is awakened and performs the following:
  - It calls the AgentGroup's *checkCollaborate* method which returns the collaboration state (either *CollaborationSucceeded* or *CollaborationFailed*, depending on the value of the waiting agent count).
  - If the collaboration failed, the collaborate method calls *recoverCollaborate*. This method attempts to communicate with the agents that did not arrive at the collaboration point by "pinging" them. (It determines these agents by comparing the list of arrived agents with the group membership.) The ping is actually performed via a message to the Conduit Server on the node where each agent was last known to be executing. If the agents are located and any of them is in the *Collaborate* state and but has not arrived at this collaboration point, a collaboration deadlock has occurred and the collaboration state is set to *CollaborationDeadlock*. If any of the agents cannot be located, the collaboration state is set to *CollaborationFailed*. Otherwise, it is set to *CollaborationRetry* and the Agent Group thread retries the collaboration up to a configurable number of times (after which the state will be set to *CollaborationFailed* if the collaboration still times out.)
  - The initiating Agent Group thread wakes up the other blocked threads by calling *notifyAll* on the AgentGroup.
6. Once all the collaborating Agent Group threads have been awakened, (either because the counter has dropped to 0 or a time-out occurred), they call the AgentGroup's *checkCollaborate* method. If this method returns a state other than *CollaborationSucceeded*, each thread returns the appropriate exception (i.e., either *CollaborationFailedException* or *CollaborationDeadlockException*) to its invoking CollaboratorAgent.
7. If the collaboration state is *CollaborationSucceeded*, collaboration commences by executing a potentially synchronized application-specific method, *analyzeResults*, to perform the collaboration. *analyzeResults* is an abstract AgentGroup method that must be implemented by derived classes to perform application-specific collaboration. As a result of collaboration, agent itineraries may be updated.
8. As each thread completes its collaboration, it replies to the remote *collaborate* invocation, passing any state specified by the implementation, (e.g., updated itineraries).
9. The agents then continue execution on their current node and travel as required by their itineraries.

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As described above, collaboration requires complex mechanisms. However, most of these are necessitated by the limited synchronization primitives provided by Java.

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## Design Specification for Distributed Java Events

*Version 0.2*

*November 12, 1996*

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# Design Specification for Distributed Java Events

*Version 0.2<sup>1</sup>*

## 1. Introduction

This document describes a general-purpose solution to distributed event management.

## 2. Overview

This section provides a high-level description of the objects that implement the distributed events framework.

### 2.1. Objects

#### Events

Events are described by classes that derive from *EventType*. Each *EventType* object includes: a unique ID (a String) generated by the constructors and a description of the event (a String) optionally passed to the constructors.

#### Event Handler

The *EventHandler* interface specifies the *handleEvent()* method which implements an Event Handler. Each application must provide its own Event Handler to perform application-specific event management.

#### Event Notification

The *EventPost* interface specifies the *postEvent()* method which implements event notification. Several of the classes described below implement this interface.

#### Event Queue

Any object receiving notification of events must own an Event Queue and an associated thread that manages the queue. The Event Queue's constructor is passed an *EventHandler* stub. It instantiates an *EventQueueThread* (a protected class derived from *Thread*) to manage the queue and passes the *EventHandler* stub to its constructor. The *EventQueueThread*'s *run()* method removes events from the queue and calls the *handleEvent()* method.

---

<sup>1</sup> Revision History:

09/26/96 Version 0.1 Initial revision.

11/12/96 Version 0.2 Expanded discussion of Event Manager and Event Group. Added Reliability Features and Garbage Collection sections.

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An Event Queue is a distributed RMI object. *EventQueueImpl* implements the *EventPost* interface by appending the specified *EventType* object to the queue and calling the associated *EventQueueThread*'s *notify()* method. This action wakes up the *EventQueueThread* (if it was blocked). The thread then proceeds to dequeue each pending event and pass it to the *handleEvent()* method.

## Event Manager

The Event Manager handles the registration, posting, and notification of events. When objects request notification of specific event types, they must pass the Event Manager a reference to their *EventPost* interface. The Event Manager saves the reference in a hash table that it uses to map event types to their notification requests. When an object posts an event (via the Event Manager's *postEvent()* method), the Event Manager obtains the list of objects to notify from the hash table and calls each of their *postEvent()* methods.

The Event Manager also maintains a list of objects that have requested notification of all events. Whenever it receives an event, the Event Manager also forwards it to these objects, by calling each of their *postEvent()* methods.

*EventManager* is an RMI distributed object. *EventManager* describes the interface, whereas *EventManagerImpl* provides the implementation. *EventManager* defines methods to manage event registrations (e.g., add and delete registrations).

*EventManagerImpl* also implements the *EventPost* interface. Its *postEvent()* method is passed an event from its originator and notifies the recipients of the event by invoking their *postEvent()* methods.

At most one Event Manager runs on each node in the Agent system. A reference to it can be obtained via the RMI Registry.

## Event Group

A group of objects interested in a common set of notifications may form an Event Group. *EventGroup* is a distributed RMI object: *EventGroup* defines the interface; *EventGroupImpl* consists of the implementation. *EventGroup* defines methods that manage the group (e.g., add and remove members).

Whereas the Event Manager filters posted events on behalf of its clients, forwarding them only the events they requested, the Event Group performs no filtering. *EventGroupImpl* implements the *EventPost* interface. However, its *postEvent()* method forwards each event it receives to every member of the group (by calling their *postEvent()* methods).

In practice, Event Groups should be used sparingly because they could allow an abusive application to generate unwanted notifications. The Agent framework does utilize this mechanism, but it verifies that all events are generated by a group member and it only utilizes the Event Group for some well-known events, such as the termination of an Agent.

Each Event Group is identified by a unique name either passed to its constructor or assigned by it. Objects may obtain a handle to a particular Event Group by presenting the RMI registry with this unique name.

## 2.2. Reliability Features

The Distributed Events framework incorporates several reliability features. These generally take the form of persistent state and proxy objects.

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## Event Manager

The Distributed Events framework shields objects from the effects of Event Manager failures in two ways:

- by saving its state (i.e., event registrations) to persistent storage, and
- by encapsulating its functionality in a proxy object.

The Event Manager saves the following items in the persistent store:

- the hash table mapping specific event types to the objects registered to receive them and
- the list of objects to be notified of all events.

Each time an object either registers or "unregisters" its interest in receiving any (or all) events, the Event Manager writes the updated event registrations (i.e., either the hash table or the list of objects, but not both) to persistent storage via the Persistent Storage Manager. These are fairly infrequent operations, so the performance impact of this process should be negligible. (See *Design Specification for Java Agent Persistence Package* for details on the Persistent Store Manager.)

Whenever the Event Manager is started, its initialization code attempts to recover any existing event registrations from persistent storage. Hence, registrations are not lost when the Event Manager fails.

In addition, the Event Manager Proxy also prevents Objects from experiencing the effects of Event Manager failures. It acts as a wrapper object for the Event Manager. Each Object wishing to communicate with the Event Manager must first create an *EventManagerProxy* object. The proxy obtains a reference to the Event Manager via the RMI Registry. If, at any point, the proxy is unable to communicate with the Event Manager, it will attempt to obtain a new reference from the registry. It will retry this operation several times before throwing an exception.

Furthermore, if the Event Manager should fail, it will automatically be re-started by the Java Agent System.

## Persistent Event Group

The Distributed Events framework provides a general-purpose implementation of Event Groups (i.e., *EventGroup*), as described above. However it also provides a reliable implementation of Event Groups: Persistent Event Groups. Persistent Event Group is a distributed RMI object that extends *EventGroup*: the interface is defined by *PersistentEventGroup* and the implementation is provided by *PersistentEventGroupImpl*, a subclass of *EventGroupImpl*. Persistent Event Group utilizes persistent storage in much the same manner as the Event Manager. Whenever an Object joins or leaves the group, it saves a reference to it in persistent storage.

Each Persistent Event Group is also encapsulated in a proxy object: *PersistentEventGroupProxy*. This proxy operates somewhat differently than the Event Manager Proxy, depending on how it is constructed. In some cases, it will attempt to locate a named Persistent Event Group in the RMI registry. If a name is not supplied to the constructor, it will create a new Persistent Event Group and register it.

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Since Event Groups are temporary objects, unlike the Event Manager, which is a persistent server, their proxies cannot expect their associated Persistent Event Groups to be automatically re-started upon failure. Hence, a proxy may re-create the group if it is unable to obtain a reference to it after sufficient retries.

This, however, introduces a race condition wherein multiple proxy objects may simultaneously attempt to re-create the Persistent Event Group. This is handled by the following mechanism:

- If the owner of the Persistent Event Group detects the failure, it re-creates the group. (The owner is defined as the proxy that initially created the group.)
- If the owner does not detect the failure in a configurable length of time, other proxies may attempt to re-create it.
- The Persistent Event Group is re-created via the following steps:
  - Attempt to create a temporary binding in the RMI name space with a well-known name derived from the Persistent Event Group's unique name.
  - If the binding does *not* return an *AlreadyBoundException*, proceed to re-create the *PersistentEventGroup* and then remove the temporary binding. (Otherwise, another proxy is re-creating it. So wait for its completion.)

### 2.3. Garbage Collection

Both the Event Manager and Event Group objects must be prepared to garbage collect stale references. This is simply performed by deleting any objects (i.e., *EventPost* stubs) that it cannot communicate with. Hence their *postEvent()* methods handle garbage collection after notifying all interested objects of the event.

## 3. Changes to Agent Implementation

### CollaboratorAgent

The *CollaboratorAgent* class contains a reference to an event queue (i.e., an *EventQueueImpl* object), which is instantiated by its constructors.

The Event Queue does not persist across an Agent's travels. Hence, its *prepareForTransit()* method flushes the queue and voids the Agent's reference to the queue before it travels. Its associated Agent Groups save any events that occur while the Agent is in-transit. The *completedTransport()* method, called after the Agent arrives at its destination, constructs a new *EventQueueImpl* object and flushes any events saved by the associated Agent Groups while the Agent was in-transit.

### AgentStatus

The *AgentStatus* class contains a reference to the *EventPost* interface implemented by the *CollaboratorAgent*'s Event Queue. It also contains an Agent's unique ID and current status. Hence, it will serve as both an Event Queue and a status indicator.

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**AgentGroupImpl**

The *AgentGroupImpl* class derives from *PersistentEventGroupImpl*. Thus, it not only enables Agent collaboration, but also provides reliable group event handling.

As a result, Agent Groups may implement different levels of persistence: Group membership is always written to persistent storage, but queued events for in-transit agents will also be saved if the Agent Group's configuration allows it.

Occasionally, the Agent Group may generate events that it directly forwards to a member of the group (e.g., to "ping" it after it fails to arrive at a collaboration point) or others that it "multicasts" to its members (e.g., an Agent's failure to reply to a ping). Group members may also broadcast an event to the group (e.g., an Agent may inform the group that it has encountered an exceptional condition).

**AgentEvent**

The *AgentEvent* class is the superclass of all events generated by Agents. It includes the Agent's unique ID.



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```

AgentGroup.java_1      Mon Nov 11 16:25:52 1996      1      10/01/96 3:40p Noemi $
1  /* $Header: /com/meitca/hsl/zonesagents/collaborate/AgentGroup.java 5
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Agent Group distributed interface.
11 *
12 * $Log: /com/meitca/hsl/zonesagents/collaborate/AgentGroup.java $
13 *
14 * 5 10/01/96 3:40p Noemi
15 * Added some javadoc comments.
16 *
17 * 4 9/10/96 5:07p Noemi
18 * Changed return value of collaborate method from a void to an Object.
19 *
20 * 3 9/06/96 3:54p Noemi
21 * Added UpdateAgent method. Changed argument to addAgent.
22 *
23 * 2 8/30/96 4:24p Noemi
24 * Added addAgent, removeAgent, and getGroupSize methods.
25 *
26 * 1 8/28/96 2:13p Noemi
27 * Basic AgentGroup functionality. No support for remote groups or agent
28 * mobility yet.
29 */
30 package com.meitca.hsl.zonesagents.collaborate;
31
32 import java.util.NoSuchElementException;
33
34 import java.rmi.Remote;
35 import java.rmi.RemoteException;
36
37 /**
38  * AgentGroup is an RMI distributed interface. The actual
39  * implementation of AgentGroup is handled by AgentGroupImpl.
40  * This class provides RMI glue that enables Agents to invoke
41  * (remote) operations on an associate agent group.
42  *
43  * Agents may belong to one or more agent coordination groups
44  * (AgentGroups), which act as focal points for distributed
45  * synchronous agent collaboration and asynchronous notifications
46
47

```

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AgentGroup.java\_1 Mon Nov 11 16:35:52 1996 2

```

48 * among members of the agent group.
49 *
50 * @see Agent
51 * @see AgentGroupImpl
52 * @author Noemi Paciorek
53 */
54
55 public interface AgentGroup
56 extends Remote {
57
58     // Instance methods
59     /**
60      * Collaboration interface.
61      * @param result The result of the agent's computation.
62      * @exception RemoteException If an error occurs setting up network
63      * connections.
64      * @exception AgentGroupException If the collaboration times out.
65      * @return An Object that describes the result of collaboration
66      */
67     public Object collaborate(AgentResult result)
68         throws RemoteException, AgentGroupException;
69
70     /**
71      * Adds an Agent to the group.
72      * @param status The AgentStatus object that describes the Agent.
73      * @exception RemoteException If an error occurs setting up network
74      * connections.
75      */
76     public void addAgent(AgentStatus status)
77         throws RemoteException;
78
79     /**
80      * Locates and removes the AgentStatus object containing the specified ID.
81      * @param agentID An Agent's unique ID.
82      * @exception RemoteException If an error occurs setting up network
83      * connections.
84      * @exception NoSuchElementException If the AgentStatus object does
85      * not exist.
86      */
87     public void removeAgent(String agentID)
88         throws RemoteException, ArrayIndexOutOfBoundsException, NoSuchElementException;
89
90     /**
91      * Replaces the AgentStatus object for the specified ID.
92      * This method may be used to change an Agent's status, ID, or both.
93      * @param agentID An Agent's unique ID
94      * @param newStatus An AgentStatus object to replace the existing one.

```

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```

AgentGroup.java_1      Mon Nov 11 16:25:52 1996      3

95  * @exception RemoteException If an error occurs setting up network
96  * connections.
97  * @exception NoSuchElementException If the AgentStatus object does
98  * not exist.
99  */
100 public void updateAgent(String agentID, AgentStatus status)
101     throws RemoteException, ArrayIndexOutOfBoundsException, NoSuchElementException;
102
103 /**
104  * Returns the number of Agents in the group.
105  * @return The number of Agents in the group.
106  * @exception RemoteException If an error occurs setting up network
107  * connections.
108  */
109 public int getGroupSize()
110     throws RemoteException;
111
112 /*
113  * TURN ON LATER
114  *
115  * public void agentException(String agentID, Exception type) throws RemoteException;
116  *
117  * public void agentTermination(String agentID) throws RemoteException;
118  */
119
120
121
122 )
123

```

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```

AgentGroupException.java_1      Mon Nov 11 16:25:52 1996      1      10/01/96 3:41p Noemi $

1  /* $Header: /com/meitca/hsl/zonesagents/collaborate/AgentGroupException.java 2
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Agent Group exceptions.
11 *
12 * $Log: /com/meitca/hsl/zonesagents/collaborate/AgentGroupException.java $
13 *
14 * 2 10/01/96 3:41p Noemi
15 * Added a protected default constructor and some javadoc comments.
16 *
17 * 1 8/28/96 2:16p Noemi
18 * AgentGroup related exceptions.
19 */
20
21 package com.meitca.hsl.zonesagents.collaborate;
22
23 import com.meitca.hsl.zonesagents.shared.Agent;
24
25 /**
26 * AgentGroupException defines exceptions that occur during
27 * AgentGroup operations.
28 *
29 * @see Agent
30 * @see AgentGroup
31 * @author Noemi Paciorek
32 */
33
34 public class AgentGroupException extends Exception {
35
36     //Constructors
37
38     /**
39     * Constructs an AgentGroupException.
40     * @exception IllegalAccessException whenever called.
41     */
42     protected AgentGroupException()
43     throws IllegalAccessException {
44
45         System.out.println("Default constructor called for AgentGroupException");
46         throw new IllegalAccessException("AgentGroupException Default constructor");
47     }

```

AgentGroupException.java\_1      Mon Nov 11 16:25:52 1996      2

```
48      /**
49       * Constructs an AgentGroupException.
50       * @param type A String describing the exception.
51       */
52      public AgentGroupException(String type) {
53          super(type);
54      }
55  }
56
57 }
```

```

AgentGroupImpl.java_1      Mon Nov 11 16:25:52 1996      1      10/01/96 3:43p Noemi S

1  /* $Header: /com/meitca/hsl/zonesagents/collaborate/AgentGroupImpl.java 7
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * Thread.currentThread().stop();
8  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
9  *
10 * DESCRIPTION
11 * Agent Group distributed class.
12 *
13 * $Log: /com/meitca/hsl/zonesagents/collaborate/AgentGroupImpl.java S
14 *
15 * 7 10/01/96 3:43p Noemi
16 * Added javadoc comments.
17 *
18 * 6 9/20/96 12:37p Noemi
19 * Added agentsWithStatus() method and some temporary retry logic to
20 * collaborate()
21 *
22 * 5 9/10/96 5:05p Noemi
23 * Changed collaborate and analyzeResults methods to return an Object.
24 *
25 * 4 9/06/96 3:53p Noemi
26 * Added removeAgent, updateAgent, and indexOfAgent methods. Changed
27 * addAgent's argument to an AgentStatus object.
28 *
29 * 3 9/04/96 3:14p Noemi
30 * Added getGroupName method.
31 *
32 * 2 8/30/96 4:28p Noemi
33 * Turned on code in constructor and finalizer that registers and
34 * deregisters with the RMI name server.
35 *
36 * 1 8/28/96 2:16p Noemi
37 * Basic synchronous agent collaboration functionality. No support for
38 * remote groups, agent mobility, or asynchronous notifications.
39 */
40
41 package com.meitca.hsl.zonesagents.collaborate;
42
43 import java.util.*;
44 import java.io.*;
45
46 import java.rmi.server.UnicastRemoteServer;
47 import java.rmi.RemoteException;

```

AgentGroupImpl.java\_1      Mon Nov 11 16:25:52 1996      2

```

48 import java.rmi.Naming;
49 import java.rmi.NotBoundException;
50
51 import java.net.InetAddress;
52
53 /**
54  * AgentGroupImpl is an RMI distributed object. This is a base class
55  * that implements the AgentGroup interfaces.
56  *
57  * Agents may belong to one or more agent coordination groups
58  * (AgentGroups), which act as focal points for distributed
59  * synchronous agent collaboration and asynchronous notifications
60  * (e.g., exceptions) among members of the agent group.
61  *
62  * @see Agent
63  * @see AgentGroup
64  * @author Noemi Paciorek
65  */
66
67 abstract public class AgentGroupImpl
68     extends UnicastRemoteServer
69     implements AgentGroup {
70
71     // Constants
72     /**
73      * Default timeout for collaboration in ms.
74      */
75     public static final long DEFAULT_TIMEOUT = 100000;
76     // public static final long DEFAULT_TIMEOUT = 5000;
77
78
79     // Class variables
80     protected static int groupId = 0;
81
82     // Instance variables
83     protected long timeout; // collaboration timeout in ms
84     protected String groupName; // name to register with RMI Name Server
85     protected Vector agentList; // Agent IDs of group members
86     protected Vector resultList; // results shared via collaborate
87     protected boolean collaborationInProgress;
88
89
90     //Constructors
91     /**
92      * Constructs an AgentGroupImpl object.
93      */
94

```

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AgentGroupImpl.java\_1      Mon Nov 11 16:25:52 1996      3

```

95 public AgentGroupImpl()
96     throws RemoteException {
97     this(DEFAULT_TIMEOUT);
98 }
99
100 /**
101  * Constructs an AgentGroupImpl object.
102  * @param timeout The collaboration timeout in milliseconds
103  */
104
105 public AgentGroupImpl(long timeout)
106     throws RemoteException {
107
108     this.timeout = (timeout > 0) ? timeout : DEFAULT_TIMEOUT;
109     agentList = new Vector();
110     resultList = null;
111     collaborationInProgress = false;
112
113     /*
114      * Create a name to represent this instance of an agent group
115      * and register it with the RMI name service.
116      */
117     groupName = "AgentGroup" + nextGroupID();
118     System.out.println("groupName = " + groupName);
119
120     try {
121         Naming.rebind(groupName, this);
122     } catch (Exception e) {
123         System.out.println("AgentGroupImpl can't rebind: " + e.getMessage());
124         e.printStackTrace();
125     }
126
127 }
128
129 // Finalizer
130 protected void finalize()
131     throws Throwable {
132
133     System.out.println("AgentGroupImpl Finalizer called");
134
135     // Remove this AgentGroup's Name from the RMI registry.
136     try {
137         Naming.unbind(groupName);
138     } catch (Exception e) {
139         System.out.println("AgentGroupImpl can't unbind: " + e.getMessage());
140         e.printStackTrace();
141     }

```



AgentGroupImpl.java\_1      Mon Nov 11 16:25:52 1996      4

```

142     )
143
144     super.finalize();
145 }
146
147
148 // Class methods
149 private final synchronized int nextGroupID() {
150     return ++groupID;
151 }
152
153
154 // Instance methods
155 /**
156  * Returns the Agent Group's unique ID.
157  * @return the Agent Group's unique ID.
158  */
159 public final String getGroupName() {
160     return groupName;
161 }
162
163
164 /**
165  * Converts an Agent Group into its string representation.
166  * @return A String representing the Agent Group
167  */
168 public String toString() {
169     return groupName;
170 }
171
172
173 // Methods to manipulate agentList.
174
175 /**
176  * Adds an Agent to the group.
177  * @param status The AgentStatus object that describes the Agent.
178  */
179 public synchronized void addAgent(AgentStatus status) {
180     agentList.addElement(status);
181     System.out.println("Added Agent, ID = " + status.getAgentID() +
182         ", Status = " + status.getStatus() + " to group");
183 }
184
185 /**
186  * Locates and removes the AgentStatus object containing the specified ID.
187  * @param agentID An Agent's unique ID.
188  * @exception NoSuchElementException If the AgentStatus object does

```

AgentGroupImpl.java\_1      Mon Nov 11 16:25:52 1996      5

```

189      * not exist.
190      */
191      public synchronized void removeAgent(String agentID)
192      throws NoSuchElementException, ArrayIndexOutOfBoundsException (
193
194      int index = indexOfAgent(agentID);
195      if (index == -1)
196          throw new NoSuchElementException("Can't find AgentID");
197      agentList.removeElementAt(index);
198      System.out.println("Removed Agent, ID = " + agentID + " from group");
199      )
200
201      /**
202      * Replaces the AgentStatus object for the specified ID.
203      * This method may be used to change an Agent's status, ID, or both.
204      * @param agentID An Agent's unique ID
205      * @param newStatus An AgentStatus object to replace the existing one.
206      * @exception NoSuchElementException If the AgentStatus object does
207      *      * not exist.
208      */
209      public synchronized void updateAgent(String agentID, AgentStatus newStatus)
210      throws NoSuchElementException, ArrayIndexOutOfBoundsException (
211
212      removeAgent(agentID);
213      addAgent(newStatus);
214      System.out.println("Updated Agent ID from " + agentID + " to New ID = " +
215      newStatus.getAgentID() + ". Status = " + newStatus.getStatus());
216      )
217
218      /**
219      * Walks the agentList looking for an AgentStatus object with the
220      * specified ID.
221      */
222      private int indexOfAgent(String agentID) {
223          int index, numAgents;
224          for (index = 0, numAgents = agentList.size(); index < numAgents; index++) {
225              AgentStatus status = (AgentStatus)agentList.elementAt(index);
226              if (agentID.compareTo(status.getAgentID()) == 0)
227                  return index;
228          }
229          return -1;
230      }
231
232      /**
233      * Determines how many agents in the group have the specified status.
234      * @param status The status value to search for.
235      * @return The number of Agent's with the specified status.

```

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AgentGroupImpl.java\_1      Mon Nov 11 16:25:52 1996      6

```

236 * @see AgentStatus
237 */
238 public int agentsWithStatus(int status) {
239     int agents = 0;
240     for (Enumeration e = agentList.elements(); e.hasMoreElements(); ) {
241         AgentStatus aStatus = (AgentStatus)e.nextElement();
242         if (aStatus.getStatus() == status)
243             agents++;
244     }
245     return agents;
246 }
247
248 /**
249  * Returns the number of Agents in the group.
250  * @return The number of Agents in the group.
251  */
252 public final int getGroupSize() {
253     return agentList.size();
254 }
255
256 // Methods to implement collaboration
257
258 /**
259  * Collaborate() is the public interface to collaboration. It calls
260  * beginCollaboration() to synchronize the recording of agent results
261  * and to wait for all agents to arrive.
262  *
263  * If all agents in the group have arrived at the collaboration
264  * point, each agent calls the application-specific analyzeResults()
265  * method to determine the agent's next course of action.
266  *
267  * Otherwise, the agent that initiated the collaborate calls
268  * recoverCollaboration().
269  *
270  * @param result The result of the agent's computation.
271  * @exception RemoteException If an error occurs setting up network
272  * connections.
273  * @exception AgentGroupException If the collaboration times out.
274  * @return An Object that describes the result of collaboration
275  */
276 public Object collaborate(AgentResult result)
277     throws RemoteException, AgentGroupException {
278     System.out.println("collaborate RMI");
279
280
281
282

```

AgentGroupImpl.java\_1      Mon Nov 11 16:25:52 1996      7

```

283 boolean firstCollaborator = beginCollaboration(result);
284
285 /*
286  * If collaboration failed and this is the agent that initiated
287  * collaboration, it woke up because its timer expired. It retries
288  * once before waking up the other agents.
289  */
290
291 //
292 if (firstCollaborator && !collaborationSucceeded()) {
293     System.out.println("Collaboration Failed. Retrying...");
294     synchronized(this) {
295         try {
296             this.wait(timeout);
297         } catch (InterruptedException e) { }
298     }
299 }
300
301 /*
302  * If all agents in the group have arrived at the collaboration
303  * point, each agent calls the application-specific analyzeResults
304  * method to determine the agent's next course of action.
305  */
306 if (collaborationSucceeded()) {
307     System.out.println("Ready to do collaboration");
308     Object collaboration = analyzeResults(resultList.elements());
309
310     /*
311     * The agent that initiated collaboration cleans up.
312     */
313     if (firstCollaborator)
314         endCollaboration();
315
316     return collaboration;
317 } else {
318     /*
319     * If this is the agent that originated the collaboration,
320     * it woke up because the timer expired. It must wake up
321     * the other blocked agents (which are still sitting in
322     * beginCollaborate()) and then recover from the error.
323     */
324     if (firstCollaborator) {
325         System.out.println("Collaboration Failed while " +
326             agentsWithStatus(AgentStatus.INTRANSIT) +
327             " agents were in transit");
328     }
329     synchronized(this) {

```

```

AgentGroupImpl.java_1      Mon Nov 11 16:25:52 1996      8

330         this.notifyAll();
331     }
332     recoverCollaboration();
333 } else
334     System.out.println("Collaboration Failed");
335
336     throw new AgentGroupException("Collaboration timed out");
337 }
338
339 )
340
341
342 /**
343  * beginCollaboration() is called internally by collaborate() to
344  * synchronize each agent's recording of results and to wait for
345  * all agents to arrive at the collaboration point. This method acts
346  * as a distributed rendezvous, of sorts. Each caller blocks until
347  * all agents in the group have "arrived" at the collaboration point.
348  *
349  * This method returns a boolean that indicates if the agent initiated
350  * the collaboration.
351  *
352  * @param result The result of the agent's computation.
353  * @exception AgentGroupException If the group only has one member.
354  * @return A boolean indicating if the collaboration was successful.
355  */
356
357 protected synchronized boolean beginCollaboration(AgentResult result)
358     throws AgentGroupException {
359     boolean firstCollaborator = false;
360
361     System.out.println("Beginning collaboration");
362
363     if (!collaborationInProgress) {
364         /*
365          * If this agent is initiating the collaboration, allocate the
366          * resultList Vector and add result to it. Then wait for all
367          * agents to arrive at the collaboration point or for the
368          * collaboration timer to expire.
369          */
370         if (AgentList.size() < 2) {
371             endCollaboration();
372             throw new AgentGroupException("AgentGroup too small");
373         }
374
375         collaborationInProgress = true;
376

```

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```

377 firstCollaborator = true;
378 resultList = new Vector();
379 resultList.addElement(result);
380
381 try {
382     this.wait(timeout);
383 } catch (InterruptedException e) { }
384
385 } else {
386
387     /*
388     * Add this agent's results to resultList. If this is the
389     * last agent to arrive, wake up the other agents. Otherwise
390     * wait for the rest of the agents in the group to arrive.
391     */
392     resultList.addElement(result);
393     if (collaborationSucceeded())
394         this.notifyAll();
395     else {
396         try {
397             this.wait();
398         } catch (InterruptedException e) { }
399     }
400 }
401
402 return firstCollaborator;
403
404
405
406 /**
407  * Cleans up after a successful collaboration.
408  */
409 protected void endCollaboration() {
410     collaborationInProgress = false;
411 }
412
413
414 /**
415  * Cleans up after a failed collaboration.
416  */
417 protected void recoverCollaboration() {
418     endCollaboration();
419 }
420
421
422
423 /**

```

```

AgentGroupImpl.java_1      Mon Nov 11 16:25:52 1996      10

    * analyzeResults() is an abstract method that must be overridden by
    * each application. It provides the application-specific behavior
    * required to implement collaboration. This method is invoked on
    * behalf of each agent in the group. It is passed the results
    * computed by each agent and determines the course of action for the
    * calling agent, if any, based on the computed results.
    *
    * @param results An Enumeration of the results computed by the agents.
    * @return Object An application-specific object or null.
    */
    abstract protected Object analyzeResults(Enumeration results);

    /**
    * Private method to determine if all agents have reached the
    * collaboration point. This method is synchronized to prevent
    * races with agents joining and leaving the group.
    */
    private synchronized boolean collaborationSucceeded() {
        return (resultList.size() == agentList.size());
    }

    /**
    * TURN ON LATER
    */
    // Methods to handle exceptions and other notifications
    public void agentException(String agentID, Exception type)
        throws RemoteException {
    }

    public void agentTermination(String agentID)
        throws RemoteException {
    }

    /**
    */
    }

```

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```

AgentResult.java_1      Mon Nov 11 16:25:52 1996      1      10/01/96 3:43p Noemi $

1  /* $Header: /com/meitca/hsl/zonesagents/collaborate/AgentResult.java 4
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * This object holds the result of an agent's computations.
11 *
12 * $Log: /com/meitca/hsl/zonesagents/collaborate/AgentResult.java $
13 *
14 * 4 10/01/96 3:43p Noemi
15 * Added some javadoc comments.
16 *
17 * 3 9/06/96 3:48p Noemi
18 * Added a protected default constructor to ensure that the public
19 * constructors set up instance variables correctly.
20 *
21 * 2 8/30/96 4:22p Noemi
22 * Changed private protected instance variables to protected.
23 *
24 * 1 8/28/96 2:17p Noemi
25 * A generic class that represents the result of an agent computation.
26 * (Used by collaboration code.)
27 */
28
29 package com.meitca.hsl.zonesagents.collaborate;
30
31 /**
32 * AgentResult contains an agent ID and a result to be shared
33 * via collaboration.
34 *
35 * @see CollaboratorAgent
36 * @see AgentGroupImpl
37 * @author Noemi Paciorek
38 */
39
40 public class AgentResult {
41
42     // Instance variables
43     protected String agentID; // ID of agent that computed result
44     protected Object result; // actual result computed
45
46     //Constructors
47     /**

```



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```

AgentResult.java_1      Mon Nov 11 16:25:52 1996      2

48  * Protected Default Constructor for an AgentResult object.
49  * @exception  IllegalAccessExpection  Whenever called.
50  */
51  protected AgentResult()
52      throws IllegalAccessExpection {
53
54      System.out.println("Default constructor called for AgentResult");
55      throw new IllegalAccessExpection("AgentResult default constructor");
56  }
57
58  /**
59   * Constructs an AgentResult object.
60   * @param  agentID  The Agent's unique ID.
61   * @param  result  The result to be shared via collaboration.
62   */
63  public AgentResult(String agentID, Object result) {
64      this.agentID = agentID;
65      this.result = result;
66  }
67
68  // Instance methods
69  /**
70   * Gets an Agent's unique ID from this AgentResult object.
71   * @return  An Agent's unique ID.
72   */
73  public final String getAgentID() {
74      return agentID;
75  }
76
77  /**
78   * Gets the result to be shared via collaboration
79   * from this AgentResult object.
80   * @return  The result to be shared via collaboration.
81   */
82  public Object getResult() {
83      return result;
84  }
85
86
87  )

```

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```

AgentStatus.java_1      Mon Nov 11 16:25:53 1996      1      10/01/96 3:44p Noemi $

1  /* $Header: /com/meitca/hsl/zonesjagents/collaborate/AgentStatus.java 2
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * This object holds an Agent's status (e.g. ACTIVE).
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/collaborate/AgentStatus.java $
13 * 2 10/01/96 3:44p Noemi
14 * Added some javadoc comments.
15 *
16 * 1 9/06/95 3:51p Noemi
17 * This class represents an agent's current status (e.g., ACTIVE).
18 *
19 */
20
21 package com.meitca.hsl.zonesjagents.collaborate;
22
23 /**
24 * AgentStatus contains an agent ID and a status value. Each AgentGroup
25 * contains an AgentStatus object for each Agent in the group.
26 *
27 * @see CollaboratorAgent
28 * @see AgentGroupImpl
29 * @author Noemi Paciorek
30 */
31
32 public class AgentStatus {
33
34     // Constants
35     private static final int FIRST_STATUS = 1;
36     /**
37     * Agent is active.
38     */
39     public static final int ACTIVE = 1;
40     /**
41     * Agent is intransit.
42     */
43     public static final int INTRANSIT = 2;
44     /**
45     * Agent is in an unknown state.
46     */
47     public static final int UNKNOWN = 3;

```

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```

AgentStatus.java_1      Mon Nov 11 16:25:53 1996      2

private static final int LAST_STATUS = UNKNOWN;

// Instance variables
protected String agentID; // ID of agent
int status; // current status

//Constructors
/**
 * Constructs an AgentStatus object.
 * @exception IllegalAccessException Whenever called.
 */
protected AgentStatus()
    throws IllegalAccessException {
    System.out.println("Default constructor called for AgentStatus");
    throw new IllegalAccessException("AgentStatus default constructor");
}

/**
 * Constructs an AgentStatus object.
 * @param agentID The Agent's unique ID.
 */
public AgentStatus(String agentID) {
    this(agentID, ACTIVE);
}

/**
 * Constructs an AgentStatus object.
 * @param agentID The Agent's unique ID.
 * @param status The Agent's status.
 */
public AgentStatus(String agentID, int status) {
    this.agentID = agentID;
    this.status = ((status < FIRST_STATUS) || (status > LAST_STATUS)) ?
        UNKNOWN : status;
}

// Instance Methods
/**
 * Extracts An Agent's unique ID from an AgentStatus object.
 * @return An Agent's unique ID.
 */
public final String getAgentID() {
    return agentID;
}

```

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3

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AgentStatus.java\_1

```
95     )
96
97     /**
98      * Extracts an Agent's current status from an AgentStatus object.
99      * @return An Agent's current status.
100     */
101     public final int getStatus() {
102         return status;
103     }
104
105 }
```

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```

CollaboratorAgent.java_1      Mon Nov 11 16:25:53 1996      1      10/01/96 3:45p Noemi S

1  /* $Header: /com/meitca/hsl/zonesjagents/collaborate/CollaboratorAgent.java 5
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Derived class for mobile Agent collaboration
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/collaborate/CollaboratorAgent.java S
13 *
14 * 5 10/01/96 3:45p Noemi
15 * Added some javadoc comments.
16 *
17 * 4 9/20/96 4:16p Noemi
18 * Changed finalizer to ensure that it performs cleanup no more than once.
19 * ( A bug in the garbage collector may cause the finalizer to be called
20 * more than once!)
21 *
22 * 3 9/10/96 5:08p Noemi
23 * Renamed setIntrinsicStatus and setActiveStatus to prepareForTransport
24 * and completedTransport, respectively.
25 *
26 * 2 9/06/96 3:57p Noemi
27 * Added the following methods: addGroup, removeGroup, updateStatus,
28 * setIntrinsicStatus, and setActiveStatus.
29 *
30 * 1 9/04/96 3:15p Noemi
31 * Subclass of Agent that implements a collaborating Agent.
32 *
33 */
34 package com.meitca.hsl.zonesjagents.collaborate;
35
36 import java.util.*;
37 import java.net.InetAddress;
38
39 import com.meitca.hsl.zonesjagents.shared.Agent;
40
41 /**
42 * A subclass of Agent that enables collaboration among Agents in a group.
43 * Agents wishing to collaborate must extend this class to do some useful work.
44 * They must also belong to an Agent coordination group (AgentGroup). Generally,
45 * an application first creates an AgentGroup. Then it obtains a reference to
46 * the RMI interface for the group by looking up the group in the local RMI name
47 * service. Subsequently, it creates new CollaboratorAgents and populates the

```

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```

CollaboratorAgent.java_1      Mon Nov 11 16:25:53 1996      2

* group with them (by passing the constructor a reference to the interface).
48 *
49 *
50 * @see Agent
51 * @see AgentGroup
52 * @author Noemi Paciorek
53 */
54 public abstract class CollaboratorAgent
55     extends Agent {
56
57     // Instance variables
58     protected Vector groupList; // AgentGroups this Agent belongs to
59
60     // Constructors
61     /**
62      * Constructs a CollaboratorAgent
63      * @exception IllegalAccessException Whenever called.
64      */
65     protected CollaboratorAgent()
66         throws IllegalAccessException {
67
68         System.out.println("Default constructor called for CollaboratorAgent");
69         throw new IllegalAccessException("CollaboratorAgent Default constructor");
70     }
71
72     /**
73      * Constructs a CollaboratorAgent
74      * @param group The AgentGroup to which this Agent belongs.
75      */
76     public CollaboratorAgent(AgentGroup group) {
77         /**
78          * Store a copy of the agentID in the AgentGroup and save a
79          * reference to the AgentGroup in groupList.
80          */
81         groupList = new Vector();
82         addGroup(group);
83     }
84
85     /**
86      * Constructs a CollaboratorAgent
87      * @param groups A list of AgentGroups to which this Agent belongs.
88      */
89     public CollaboratorAgent(Vector groups) {
90         this(groups, null);
91     }
92
93
94

```

CollaboratorAgent.java\_1      Mon Nov 11 16:25:53 1996      3

```

95  /**
96   * Constructs a CollaboratorAgent
97   * @param groups A list of AgentGroups to which this Agent belongs.
98   * @param cidID The unique ID of an agent to be replaced by this agent.
99   */
100 public CollaboratorAgent(Vector groups, String oldID) {
101     /*
102     * Save a copy of agentID in each of the associated AgentGroups and
103     * store a reference to each AgentGroup in groupList.
104     */
105     groupList = new Vector();
106     for (Enumeration e = groups.elements(); e.hasMoreElements(); ) {
107         AgentGroup group = (AgentGroup)e.nextElement();
108         groupList.addElement(group);
109     }
110     try {
111         if (oldID == null)
112             group.addAgent(new AgentStatus(agentID));
113         else
114             group.updateAgent(oldID, new AgentStatus(agentID));
115         System.out.println("Group size = " + group.getGroupSize());
116     } catch (Exception ex) {
117         System.out.println("Agent constructor: can't add agent to group: " +
118             ex.getMessage());
119         System.out.println("AgentID = " + agentID + ", oldID = " + oldID);
120         ex.printStackTrace();
121     }
122 }
123
124 // Finalize:
125 protected void finalize()
126     throws Throwable {
127     System.out.println("CollaboratorAgent Finalizer called");
128 }
129
130 /**
131 * Remove agentID from all groups this agent belongs to.
132 */
133 if (groupList != null) {
134     for (Enumeration e = groupList.elements(); e.hasMoreElements(); ) {
135         AgentGroup group = (AgentGroup)e.nextElement();
136         try {
137             group.removeAgent(agentID);
138         } catch (Exception ex) {
139
140
141

```

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```

CollaboratorAgent.java_1      Mon Nov 11 16:25:53 1996      4

142      System.out.println("CollaboratorAgent finalizer: can't remove agent from group: " +
143      ex.getMessage());
144      ex.printStackTrace();
145      }
146      groupList = null; // in case finalizer gets called twice (it has been!)
147      super.finalize();
148      }
149      // Instance methods
150      /**
151      * Returns a list of groups the CollaboratorAgent belongs to.
152      * @return The list of groups this CollaboratorAgent belongs to.
153      */
154      public final synchronized Enumeration getGroups() {
155      return groupList.elements();
156      }
157      /**
158      * Add a group to this agent's groupList and add the agent
159      * to the group's agent list.
160      * @param group The group to be added.
161      */
162      public synchronized void addGroup(AgentGroup group) {
163      groupList.addElement(group);
164      }
165      try {
166      group.addAgent(new AgentStatus(agentID));
167      System.out.println("Group size = " + group.getGroupSize());
168      } catch (Exception ex) {
169      System.out.println("Can't add agent to group: " + ex.getMessage());
170      ex.printStackTrace();
171      }
172      /**
173      * Remove a group from this agent's groupList and remove the agent
174      * from the group's agent list.
175      * @param group The group to be removed.
176      */
177      public synchronized void removeGroup(AgentGroup group) {
178      groupList.removeElement(group);
179      }
180      try {
181      group.removeAgent(agentID);
182      } catch (Exception ex) {
183      }
184      }
185      }
186      }
187      }
188

```



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```

CollaboratorAgent.java_1      Mon Nov 11 16:25:53 1996      5

189      System.out.println("Can't remove agent from group: " + ex.getMessage());
190      ex.printStackTrace();
191  )
192  )
193  )
194  )
195  /**
196   * Update an agent's status in all groups it belongs to.
197   * @param status The new status.
198   */
199  public synchronized void updateStatus(int status) {
200      if (groupList != null)
201          for (Enumeration e = groupList.elements(); e.hasMoreElements(); ) {
202              AgentGroup group = (AgentGroup)e.nextElement();
203              try {
204                  group.updateAgent(agentID, new AgentStatus(agentID, status));
205              } catch (Exception ex) {
206                  System.out.println("CollaboratorAgent finalizer: can't remove agent from group: " +
207                      ex.getMessage());
208                  ex.printStackTrace();
209              }
210          }
211  )
212  )
213  /**
214   * Set an agent's status to INTRANSIT before transport.
215   */
216  public void prepareForTransport() {
217      updateStatus(AgentStatus.INTRANSIT);
218  }
219  )
220  )
221  /**
222   * Set an agent's status to ACTIVE after transport.
223   */
224  public void completedTransport() {
225      updateStatus(AgentStatus.ACTIVE);
226  }
227  )
228  )

```

```

EventException.java_1      Mon Nov 11 16:26:41 1996      1      10/14/96 5:55p Noemi $

1  /*  $Header: /com/meitca/hsl/zonesjagents/event/EventException.java 1
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Event exceptions
11 *
12 *      $Log: /com/meitca/hsl/zonesjagents/event/EventException.java $
13 *
14 * 1    10/14/96 6:55p Noemi
15 * Base class for exceptions generated during event processing.
16 */
17 package com.meitca.hsl.zonesjagents.event;
18
19 /**
20 * Exceptions encountered by Events.
21 *
22 * @see EventType
23 * @author Noemi Paciorek
24 */
25
26 public class EventException extends Exception {
27
28     // Constructors
29     /**
30      * Constructs an EventException.
31      * @exception IllegalAccessException Whenever called.
32      */
33     protected EventException()
34     throws IllegalAccessException {
35
36         System.out.println("Default constructor called for EventException");
37         throw new IllegalAccessException("EventException Default constructor");
38     }
39
40     /**
41      * Constructs an EventException.
42      * @param type A String describing the exception.
43      */
44     public EventException(String type) {
45         super(type);
46     }
47

```

```

EventGroup.java_1      Mon Nov 11 16:26:41 1996      1      10/14/96 6:59p Noemi S

1  /* $Header: /com/meitca/hsl/zonesjagents/event/EventGroup.java 1
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center: America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Event Group distributed interface.
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/event/EventGroup.java $
13 *
14 * 1    10/14/96 6:59p Noemi
15 * Event Group interface.
16 *
17 */
18
19 package com.meitca.hsl.zonesjagents.event;
20
21 import java.util.NoSuchElementException;
22
23 import java.rmi.Remote;
24 import java.rmi.RemoteException;
25
26 /**
27  * EventGroup is a distributed RMI interface for event groups.
28  *
29  * An EventGroup consists of a group of objects that wish to receive
30  * events generated by the other members of the group. The EventGroup
31  * serves as a gateway between the objects in the group and forwards
32  * events posted to it to the members of the group.
33  *
34  * The members of the group must all implement the EventPost interface.
35  *
36  * @see EventGroupImp1
37  * @author Noemi Paciorek
38  */
39
40 public interface EventGroup
41     extends Remote {
42
43     /**
44      * Adds a member to the event group.
45      * @param object An Object that implements the EventPost interface.
46      * @exception RemoteException If an error occurs setting up network
47      * connections.

```

```
EventGroup.java_1      Mon Nov 11 16:26:41 1996      2

48  * @exception ClassCastException If object does not implement EventPost.
49  */
50  public void addMember(Object object)
51  throws RemoteException, ClassCastException;
52
53  /**
54  * Removes a member from the group
55  * @param object The Object to remove
56  * @exception RemoteException If an error occurs setting up network
57  * connections
58  * @exception NoSuchElementException If object is not a member of the group.
59  */
60  public void removeMember(Object object)
61  throws RemoteException, NoSuchElementException;
62
63  )
```

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```

EventGroupImpl.java_1      Mon Nov 11 16:26:41 1996      1      10/22/96 7:10p Noemi S

1  /* $Header: /com/meitca/hsl/zonesjagents/event/EventGroupImpl.java 2
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Event Group distributed object.
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/event/EventGroupImpl.java $
13 *
14 * 2 10/22/96 7:10p Noemi
15 * Changed the throws clause of the postEvent method.
16 *
17 * 1 10/14/96 8:59p Noemi
18 * Event group implementation.
19 *
20 */
21
22 package com.meitca.hsl.zonesjagents.event;
23
24 import java.util.*;
25 import java.io.*;
26
27 import java.rmi.server.UnicastRemoteServer;
28 import java.rmi.RemoteException;
29 import java.rmi.Naming;
30 import java.rmi.AlreadyBoundException;
31 import com.meitca.hsl.util.UniqueID;
32
33 /**
34  * EventGroupImpl is an RMI distributed object that implements
35  * Event Group and EventPost.
36  *
37  * An EventGroup consists of a group of objects that wish to receive
38  * events generated by the other members of the group. The EventGroup
39  * serves as a gateway between the objects in the group and forwards
40  * events posted to it to the members of the group.
41  *
42  * The members of the group must all implement the EventPost interface.
43  *
44  * @see EventGroup
45  * @author Noemi Pacinrek
46  */

```

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EventGroupImpl.java\_1      Mon Nov 11 16:26:41 1996      2

```

48  */
49
50  public class EventGroupImpl
51      extends UnicastRemoteServer
52      implements EventGroup, EventPost {
53
54      // Instance variables
55
56      /** A list of the group's members. */
57      protected Vector memberList;
58
59      // Constructors
60      /**
61       * Constructs an EventGroupImpl object.
62       * @exception RemoteException If an error occurs setting up network
63       * connections.
64       */
65      public EventGroupImpl()
66      throws RemoteException {
67          /*
68           * Create member list and event queue.
69           */
70          memberList = new Vector();
71      }
72
73      // Instance methods
74
75      // EventGroup methods
76      /**
77       * Add a member to the event group.
78       * @param Object An Object that implements the EventPost interface.
79       * @exception ClassCastException If object does not implement EventPost.
80       */
81      public synchronized void addMember(Object object)
82      throws ClassCastException {
83
84          try {
85              EventPost eventPost = (EventPost)object;
86          } catch (ClassCastException e) {
87              System.out.println("addMember: Object does not implement Event Post");
88              throw e;
89          }
90          memberList.addElement(object);
91      }
92
93      /**
94

```

```

EventGroupImpl.java_1      Mon Nov 11 16:26:41 1996      3

95      * Remove a member from the group
96      * @param object The Object to remove
97      * @exception NoSuchElementException If object is not a member of the group.
98      */
99      public synchronized void removeMember(Object object)
100      throws NoSuchElementException {
101
102          if (!memberList.removeElement(object))
103              throw new NoSuchElementException("Object not member of group");
104      }
105
106
107      // EventPost methods
108      /**
109       * Forward an event to all members of the group.
110       * @param event The event to post.
111       * @exception EventException If an error occurs posting the event.
112       */
113      public void postEvent(EventType event)
114      throws RemoteException, EventException, IOException {
115
116          for (Enumeration e = memberList.elements(); e.hasMoreElements(); ) {
117              EventPost eventQueue = (EventPost)e.nextElement();
118              eventQueue.postEvent(event);
119          }
120      }
121
122      )

```

```

EventHandler.java_1      Mon Nov 11 16:26:41 1996      1      10/14/96 6:56p Noemi $

1  /* $Header: /com/meitca/hsl/zonesjagents/event/EventHandler.java 1
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Event handler interface
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/event/EventHandler.java $
13 *
14 * 1 10/14/96 6:56p Noemi
15 * Event handler interface.
16 */
17 package com.meitca.hsl.zonesjagents.event;
18
19 import java.rmi.Remote;
20 import java.rmi.RemoteException;
21
22 /**
23  * EventHandler is a distributed RMI interface for handling events.
24  *
25  * @author Noemi Paciorek
26  */
27
28 public interface EventHandler {
29
30     // Instance methods.
31     /**
32      * Event handler interface.
33      * @param event Current event.
34      * @exception RemoteException If an error occurs setting up network
35      * connections.
36      * @exception EventException If an error occurs handling the event.
37      */
38     public void handleEvent(EventType event)
39         throws RemoteException, EventException;
40
41 }
42

```



```

EventManager.java_1      Mon Nov 11 16:26:41 1996      1      10/22/96 7:12p Noemi S
1  /* $Header: /com/meitca/hsl/zonesjagents/event/EventManager.java 2
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL ANT. PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Event Manager Interface
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/event/EventManager.java $
13 *
14 * 2      10/22/96 7:12p Noemi
15 * Changed registerEvents and unregisterEvents to take an array of
16 * Strings, rather than an array of EventType. Also changed several of
17 * the throws clauses.
18 *
19 * 1      10/14/96 6:58p Noemi
20 * Event Manager interface.
21 */
22
23 package com.meitca.hsl.zonesjagents.event;
24
25 import java.io.*;
26 import java.rmi.Remote;
27 import java.rmi.RemoteException;
28
29 /**
30 * EventManager is a distributed RMI interface for event management.
31 *
32 * @see EventManagerImpl
33 * @author Noemi Packorek
34 */
35
36 public interface EventManager
37 extends Remote {
38
39     // Instance methods.
40     // Methods used to register interest in specified events.
41
42     /**
43      * Register interest in receiving specified events.
44      * @param events An array of the names of events that an object
45      * is interested in receiving.
46      * @param eventQueue The associated event queue's EventPost interface.
47      * @exception RemoteException If an error occurs setting up network

```

EventManager.java\_1      Mon Nov 11 16:26:41 1996      2

```

48      * connections.
49      */
50      public void registerEvents(String events[], EventPost eventQueue)
51          throws RemoteException, IOException;
52
53      /**
54       * Register interest in receiving all events posted to this EventManager.
55       * @param eventQueue The associated event queue's EventPost interface.
56       * @exception RemoteException If an error occurs setting up network
57       * connections.
58       */
59      public void registerAll(EventPost eventQueue)
60          throws RemoteException, IOException;
61
62      // Methods to unregister events.
63      /**
64       * Remove registration for specified events.
65       * @param events An array of the names of events that an object
66       * is no longer interested in receiving.
67       * @param eventQueue The associated event queue's EventPost interface.
68       * @exception RemoteException If an error occurs setting up network
69       * connections.
70       * @exception EventManagerException If the event queue was not registered
71       * for one or more of the specified exceptions.
72       */
73      public void unregisterEvents(String events[], EventPost eventQueue)
74          throws RemoteException, IOException, EventManagerException;
75
76      /**
77       * Remove registration for all events.
78       * @param eventQueue The associated event queue's EventPost interface.
79       * @exception RemoteException If an error occurs setting up network
80       * connections.
81       */
82      public void unregisterAll(EventPost eventQueue)
83          throws RemoteException, IOException;
84
85      )

```

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```

EventManagerException.java_1      Mon Nov 11 16:26:41 1996      1      10/14/96 6:57p Noemi $

1 /* $Header: /com/meitca/hsl/zonesjagents/event/EventManagerException.java 1
2 *
3 * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4 * Information Technology Center America.
5 * All rights reserved.
6 *
7 * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8 *
9 * DESCRIPTION
10 * EventManager exceptions.
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/event/EventManagerException.java $
13 *
14 * 1 10/14/96 6:57p Noemi
15 * Exceptions generated by the Event Manager.
16 */
17 package com.meitca.hsl.zonesjagents.event;
18
19 /**
20 * Exceptions encountered by the EventManager.
21 *
22 * @see EventMangerImpl
23 * @author Noemi Paciorek
24 */
25
26 public class EventManagerException extends EventException {
27
28     // Constructors
29     /**
30      * Constructs an EventManagerException.
31      * @exception IllegalArgumentException Whenever called.
32      */
33     protected EventManagerException()
34     throws IllegalArgumentException {
35
36         System.out.println("Default constructor called for EventManagerException");
37         throw new IllegalArgumentException("EventManagerException Default constructor");
38     }
39
40     /**
41      * Constructs an EventManagerException.
42      * @param type A String describing the exception.
43      */
44     public EventManagerException(String type) {
45         super(type);
46     }
47

```

2

Mon Nov 11 16:26:41 1996

EventManagerException.java\_1

48  
49  
50  
51  
52

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```

EventManagerImpl.java_1      Mon Nov 11 16:26:42 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/event/EventManagerImpl.java 3 10/24/96 4:57p Noemi $
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Event Manager distributed object.
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/event/EventManagerImpl.java $
13 *
14 * 3 10/24/96 4:57p Noemi
15 * Added support for an Event Manager properties file and properties that
16 * specify if persistence is enabled and the name of the persistent
17 * storage file.
18 *
19 * 2 10/22/96 7:28p Noemi
20 * Save full and specific event registrations to persistent storage.
21 * Constructor reads persistent data and reconstructs notifications.
22 * EventManager removes event queues that it can't post events to.
23 * Changed registerEvents and unregisterEvents to take an array of String.
24 * Made constructor protected and added a main method.
25 * Perform cleanup when receiving conflicting registrations (full vs.
26 * specific).
27 *
28 * 1 10/14/96 6:58p Noemi
29 * The Event Manager.
30 */
31
32 package com.meitca.hsl.zonesjagents.event;
33
34 import java.util.*;
35 import java.io.*;
36
37 import java.rmi.server.UnicastRemoteServer;
38 import java.rmi.RemoteException;
39 import java.rmi.Naming;
40 import java.rmi.NotBoundException;
41 import java.rmi.AlreadyBoundException;
42
43 import com.meitca.hsl.zonesjagents.shared.*;
44
45 import com.meitca.hsl.zonesjagents.security.InsecurityManager;
46
47

```

```

EventManagerImpl.java_1      Mon Nov 11 16:26:42 1996      2

48 /**
49  * EventManagerImpl is an Event Manager that implements the RMI
50  * EventManager and EventPost interfaces.
51  *
52  * This class allows objects to register their interest in receiving
53  * specified events and to delete their registrations.
54  *
55  * Objects post events by calling the EventManager's postEvent method
56  * (defined by the EventPost interface).
57  *
58  * The EventManager is a sentinel object (i.e., there is only one
59  * per system.
60  *
61  * @see EventManager
62  * @see EventPost
63  * @see EventHandler
64  * @see EventManagerProxy
65  * @author Noemi Racioerek
66  */
67
68 public class EventManagerImpl
69     extends UnicastRemoteServer
70     implements EventManager, EventPost {
71
72     // Constants
73     private static final String EVENT_MANAGER_NAME = "EventManager";
74
75     private static final String PROPERTIES_DESCRIPTION = "Properties File for EventManager";
76     private static final String ENABLE_PERSISTENCE = "EventManager.persistence.Enable";
77     private static final String PERSISTENCE_FILE = "EventManager.persistence.FileName";
78     // private static final String DEFAULT_PERSISTENCE_FILE = "C:\\temp\\EventManager.store";
79     private static final String DEFAULT_PERSISTENCE_FILE = "EventManager.store";
80
81     /* IDs for persistent objects */
82     private static final int EVENT_REGISTRATION_ID = 1;
83     private static final int FULL_REGISTRATION_ID = 2;
84
85     private static final int STORAGE_PADDING = 1024;
86
87     // Instance variables
88
89
90
91     /**
92     * Hash table that maps class names derived from EventType to
93     * registered EventPost stubs.
94     */

```

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```

EventManagerImpl.java_1      Mon Nov 11 16:26:42 1996      3

protected Hashtable eventRegistrations:
95
96
97 /** List of EventPost stubs registered to receive all notifications. */
98 protected Vector fullRegistrations:
99
100 /**
101  * Hash table that maps an EventPost stub to the list of events it
102  * is registered for. (Actually, it maps the stub to the class name of
103  * the event).
104  */
105 protected Hashtable eventNotifications:
106
107 /** A reference to this EventManager's persistent store handler. */
108 protected PersistentStoreHandler persistenceManager:
109
110 /** Name of the persistent storage file */
111 protected String persistentStoreFile:
112
113 /** The properties file */
114 protected JASProperties properties:
115
116 // Constructors
117 /**
118  * Constructs an EventManager. EventManagerImpl has no public
119  * constructors. Applications wishing to utilize the Event Manager's
120  * services must access it via EventManagerProxy.
121  */
122 protected EventManagerImpl()
123 throws Exception {
124
125     /* Locate properties file.
126     */
127     try {
128         properties = new JASProperties(EVENT_MANAGER_NAME,
129                                     JASProperties.SERVER, PROPERTIES_DESCRIPTION, false);
130         System.out.println("EventManagerImpl: Located properties file");
131     } catch (Exception e) {
132         System.out.println("EventManagerImpl: Couldn't access Properties file for Conduit Ser
133         System.out.println("\tContinuing with defaults.");
134         // Construct an empty Properties object.
135         properties = new JASProperties();
136     }
137
138 /**
139  * Recover event and full registrations from persistent storage.
140
141

```

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```

EventManagerImpl.java_1      Mon Nov 11 16:26:42 1996      4

142      * if required. Then reconstruct event notifications.
143      */
144      recoverRegistrations();
145
146      /*
147      * Register this instance with the RMI registry.
148      */
149      try {
150          Naming.rebind(EVENT_MANAGER_NAME, this);
151      } catch (Exception e) {
152          System.out.println("EventManagerImpl can't bind " + EVENT_MANAGER_NAME + ": " + e.getMessage());
153          e.printStackTrace();
154          throw e;
155      }
156
157      )
158
159      // Finalizer
160      /**
161      * Removes the EventManager's entry from the RMI registry.
162      */
163      protected void finalize()
164      throws Throwable {
165
166          System.out.println("EventManagerImpl Finalizer called");
167
168          // Remove this EventManager's Name from the RMI registry.
169          try {
170              Naming.unbind(EVENT_MANAGER_NAME);
171          } catch (Exception e) {
172              System.out.println("EventManagerImpl can't unbind: " + e.getMessage());
173              e.printStackTrace();
174          }
175
176          // Delete reference to Persistent Store Manager.
177          persistenceManager = null;
178          super.finalize();
179      }
180
181      // Instance methods
182
183      // Methods to add event registrations.
184      /**
185      * Register interest in receiving specified events.
186      */
187
188

```



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```

EventManagerImpl.java_1      Mon Nov 11 16:26:42 1996      5

189  * To remove these registrations use
190  * unregisterEvents(EventType events[], EventPost eventQueue).
191  * @param events    An array of the names of events that an object
192  * is interested in receiving.
193  * @param eventQueue The associated event queue's EventPost interface.
194  */
195 public synchronized void registerEvents(String events[], EventPost eventQueue)
196     throws IOException {
197
198     /*
199     * If the event queue has already registered to receive all
200     * notifications, ignore this request.
201     */
202     if (fullRegistrations.contains(eventQueue))
203         return;
204
205     /*
206     * Get the list of events the queue has registered
207     * for notification. If the list does not exist, create it.
208     */
209     Vector notifyList = (Vector)eventNotifications.get(eventQueue);
210     if (notifyList == null) {
211         notifyList = new Vector();
212         eventNotifications.put(eventQueue, notifyList);
213     }
214
215     for (int i = 0; i < events.length; i++) {
216         String eventName = events[i];
217         System.out.println("registerEvents, event = " + eventName);
218
219         /*
220         * Add the event to the queue's list of registered events.
221         */
222         if (notifyList.contains(eventName)) {
223             System.out.println("registerEvents, adding event name to notify list");
224             notifyList.addElement(eventName);
225         }
226
227         /*
228         * Look up the event name in the eventRegistrations hash table
229         * and add the queue to the list of registered Objects for the event.
230         */
231         Vector registryList = (Vector)eventRegistrations.get(eventName);
232         if (registryList == null) {
233             registryList = new Vector();
234             eventRegistrations.put(eventName, registryList);
235             System.out.println("registerEvents, adding event queue to registry list");

```

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```

EventManagerImpl.java_1    Mon Nov 11 16:26:42 1996    6

    registryList.addElement(eventQueue);
    } else if (!registryList.contains(eventQueue)) {
        System.out.println("registerEvents, adding event queue to registry list");
        registryList.addElement(eventQueue);
    }
}
/*
 * Write the updated eventRegistrations table to
 * persistent storage.
 */
updateEventRegistrations();
}

/**
 * Register interest in receiving all events posted to this EventManager.
 * To remove these registrations use
 * unregisterAll(EventPost eventQueue).
 * @param eventQueue The associated event queue's EventPost interface.
 */
public synchronized void registerAll(EventPost eventQueue)
    throws IOException {
    System.out.println("registerAll");
}
/*
 * If this event queue already registered to receive
 * specific registrations, remove them.
 */
if ((Vector)eventNotifications.get(eventQueue) != null)
    unregisterAll(eventQueue);
}
/*
 * If the event queue has already been registered for
 * all notifications, ignore this request.
 * Otherwise add the queue the the list of full registrations.
 */
if (!fullRegistrations.contains(eventQueue)) {
    System.out.println("registerAll, adding event queue to full registrations");
    fullRegistrations.addElement(eventQueue);
}
/*
 * Write the updated fullRegistrations list to
 * persistent storage.
 */
updateFullRegistrations();
}
236
237
238
239
240
241
242
243
244
245
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248
249
250
251
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253
254
255
256
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280
281
282

```

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EventManagerImpl.java\_1 Mon Nov 11 16:26:42 1996 7

```

283     )
284
285     // Methods to remove registrations.
286
287     /**
288     * Remove registration for specified events.
289     * @param events An array of the names of events that an object
290     * is no longer interested in receiving.
291     * @param eventQueue The associated event queue's EventPost interface.
292     * @exception EventManagerException If the event queue was not registered
293     * for one or more of the specified exceptions.
294     */
295     public synchronized void unregisterEvents(String events[], EventPost eventQueue)
296     throws EventManagerException, IOException {
297
298         /**
299         * Get the list of events the queue has registered
300         * for notification.
301         */
302         Vector notifyList = (Vector)eventNotifications.get(eventQueue);
303         if (notifyList == null)
304             throw new EventManagerException("Bad event queue");
305
306         for (int i = 0; i < events.length; i++) {
307             String eventName = events[i];
308             System.out.println("unregisterEvents, event = " + eventName);
309
310             /**
311             * Remove the event from the queue's list of registered events.
312             */
313             System.out.println("unregisterEvents, removing event name from notify list");
314             notifyList.removeElement(eventName);
315
316             /**
317             * Look up the event name in the eventRegistrations hash table
318             * and remove the queue from the list of registered Objects for
319             * the event. If the list is empty, remove the event's hash
320             * table entry.
321             */
322             Vector registryList = (Vector)eventRegistrations.get(eventName);
323             if (registryList == null)
324                 throw new EventManagerException("Bad event");
325
326             System.out.println("unregisterEvents, removing event queue from registry list");
327             registryList.removeElement(eventQueue);
328
329

```

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```

EventManagerImpl.java_1      Mon Nov 11 16:26:42 1996      8

330         if (registryList.isEmpty()) {
331             System.out.println("unregisterEvents, removing hash table entry for event " + eventName);
332             eventRegistrations.remove(eventName);
333         }
334     }
335
336     /**
337      * Write the updated eventRegistrations table to
338      * persistent storage.
339      */
340     updateEventRegistrations();
341
342     /**
343      * If the queue's list of registered events is empty, remove
344      * the queue's hash table entry.
345      */
346     if (notifyList.isEmpty()) {
347         System.out.println("unregisterEvents, removing event queue's hash table entry");
348         eventNotifications.remove(eventQueue);
349     }
350 }
351
352 /**
353  * Remove registration for all events.
354  * @param eventQueue The associated event queue's EventPost interface.
355  * This method is often called by finalizers, so it ignores errors.
356  */
357 public synchronized void unregisterAll(EventPost eventQueue)
358     throws IOException {
359     if (fullRegistrations.contains(eventQueue)) {
360         /**
361          * If the event queue was registered to receive all registrations,
362          * remove it from the fullRegistrations hash table.
363          */
364         System.out.println("unregisterAll, removing full registration");
365         fullRegistrations.removeElement(eventQueue);
366     }
367
368     /**
369      * Write the updated fullRegistrations list to
370      * persistent storage.
371      */
372     updateFullRegistrations();
373 } else {
374     /**
375      * Locate the event queue's list of registered events.
376

```

EventManagerImpl.java\_1 Mon Nov 11 16:26:42 1996 9

```

377 */
378 Vector notifyList = (Vector)eventNotifications.get(eventQueue);
379 if (notifyList == null)
380     return;
381
382 System.out.println("unregisterAll, removing event registrations");
383
384 for (Enumeration e = notifyList.elements(); e.hasMoreElements(); ) {
385     String eventName = (String)e.nextElement();
386     System.out.println("unregisterAll, event = " + eventName);
387
388     Vector registryList = (Vector)eventRegistrations.get(eventName);
389     if (registryList == null)
390         continue;
391
392     /* For each event in the list, remove the queue from the
393      * event's list of registered Objects.
394      * If the list is empty, remove the event's hash table entry.
395      */
396     System.out.println("removing event queue from registry list");
397     registryList.removeElement(eventQueue);
398     if (registryList.isEmpty()) {
399         System.out.println("unregisterAll, removing hash table entry for event " + eventName);
400         eventRegistrations.remove(eventName);
401         registryList = null;
402     }
403 }
404
405 /**
406  * Write the updated eventRegistrations table to
407  * persistent storage.
408  */
409 updateEventRegistrations();
410
411 /**
412  * Remove the event queue's hash table entry.
413  */
414 System.out.println("unregisterAll, removing event queue's hash table entry");
415 eventNotifications.remove(eventQueue);
416 }
417
418 // Methods to post events and send notifications
419
420 /**
421  * Notify objects that an event occurred (EventPost interface).
422  */
423

```

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```

EventManagerImpl.java_1      Mon Nov 11 16:26:42 1996      10

424 * @param event Event being posted.
425 * @exception EventException If an error occurs posting the event.
426 */
427 public synchronized void postEvent(EventType event)
428     throws RemoteException, EventException, IOException {
429     System.out.println("EventManager, posting event");
430 }
431 /*
432  * Handle specific registrations for this event. Locate this event's
433  * entry in the eventRegistrations hash table and post the event to
434  * each of the event queues on its hash chain.
435  */
436 String eventName = event.getClass().getName();
437 System.out.println("postEvent, event = " + eventName);
438
439 System.out.println("postEvent, checking specific registrations");
440
441 /*
442  * Post the event to the event queues registered to
443  * receive it.
444  */
445 Vector badEventRegistrations = new Vector();
446
447 Vector registryList = (Vector)eventRegistrations.get(eventName);
448 if (registryList != null) {
449     System.out.println("registryList contains " + registryList.size() +
450         " elements");
451     for (Enumeration e = registryList.elements(); e.hasMoreElements(); ) {
452         EventPost eventQueue = (EventPost)e.nextElement();
453         System.out.println("Posting event");
454         try {
455             eventQueue.postEvent(event);
456         } catch (Exception e2) {
457             System.out.println("Event post failed");
458             badEventRegistrations.addElement(eventQueue);
459         }
460     }
461 }
462
463 /*
464  * Post the event to all Objects that have requested notification
465  * of all events.
466  */
467 System.out.println("postEvent, checking full registrations");
468
469
470

```

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```

EventManagerImpl.java_1      Mon Nov 11 16:26:42 1996      11

    System.out.println("fullRegistrations contains " + fullRegistrations.size() +
        " elements");

    Vector badFullRegistrations = new Vector();
    for (Enumeration e = fullRegistrations.elements(); e.hasMoreElements(); ) {
        EventPost eventQueue = (EventPost)e.nextElement();

        System.out.println("Posting event");
        try {
            eventQueue.postEvent(event);
        } catch (Exception e3) {
            System.out.println("Event post failed");
            badFullRegistrations.addElement(eventQueue);
        }
    }

    /*
     * If the EventManager was unable to contact any event queues,
     * remove them from eventRegistrations and/or fullRegistrations
     * and update the affected registrations in persistent storage.
     */
    if (!badEventRegistrations.isEmpty()) {
        for (Enumeration e = badEventRegistrations.elements(); e.hasMoreElements(); ) {
            EventPost eventQueue = (EventPost)e.nextElement();
            System.out.println("Removing bad event queue from registry list");
            registryList.removeElement(eventQueue);
        }
        updateEventRegistrations();
    }
    badEventRegistrations = null;

    if (!badFullRegistrations.isEmpty()) {
        for (Enumeration e = badFullRegistrations.elements(); e.hasMoreElements(); ) {
            EventPost eventQueue = (EventPost)e.nextElement();
            System.out.println("Removing bad event queue from full list");
            fullRegistrations.removeElement(eventQueue);
        }
        updateFullRegistrations();
    }
    badFullRegistrations = null;

}

// Methods to handle persistence.
/**

```

EventManagerImpl.java\_1 Mon Nov 11 16:26:42 1996 12

```

518 * Allocate a persistent store manager and restore
519 * eventRegistrations and fullRegistrations. (If they
520 * don't exist in the persistent store, instantiate
521 * new ones.) Then reconstruct eventNotifications from
522 * eventRegistrations.
523 */
524 protected void recoverRegistrations() {
525     Boolean enabled = new Boolean(getProperty(ENABLE_PERSISTENCE, "false"));
526     if (!enabled.booleanValue()) {
527         /*
528          * If persistence is disabled, perform initialization,
529          * but not recovery.
530          */
531         System.out.println("recoverRegistrations: persistence disabled");
532         persistentStoreFile = "";
533         persistenceManager = null;
534         eventRegistrations = new Hashtable();
535         fullRegistrations = new Vector();
536         eventNotifications = new Hashtable();
537         return;
538     }
539
540     System.out.println("Persistence enabled.");
541     persistentStoreFile = getProperty(PERSISTENCE_FILE, "");
542     System.out.println("EventManager.persistence.FileName property set to: " + persistentStoreFile);
543
544     /*
545      * If no file is specified, use the default.
546      */
547     if (persistentStoreFile.length() == 0)
548         persistentStoreFile = AgentConstants.AGENT_DIR + DEFAULT_PERSISTENCE_FILE;
549     System.out.println("Persistent Store File: " + persistentStoreFile);
550
551     persistenceManager = new PersistentStoreHandler(persistentStoreFile);
552
553     /*
554      * Fetch registrations from the persistent store. If they don't exist,
555      * instantiate eventRegistrations and fullRegistrations.
556      */
557     System.out.println("Fetching eventRegistrations");
558     if ((eventRegistrations =
559         (Hashtable)persistenceManager.fetchObject(EVENT_REGISTRATION_ID)) == null)
560         eventRegistrations = new Hashtable();
561
562     System.out.println("Fetching fullRegistrations");
563     if ((fullRegistrations =
564 
```



```

EventManagerImpl.java_1      Mon Nov 21 16:26:42 1996      13

    (Vector)persistenceManager.fetchObject(FULL_REGISTRATION_ID) == null)
    fullRegistrations = new Vector();

    /**
     * Reconstruct the event notifications using event registrations. Then
     * truncate the persistent store and write out the registrations.
     */
    System.out.println("Reconstructing event notifications");
    reconstructNotifications();

    System.out.println("Saving registrations");
    saveRegistrations();
}

/**
 * Truncate persistent storage and write out event and full
 * registrations.
 */
protected void saveRegistrations() {
    if (persistenceManager == null)
        return;

    persistenceManager.truncateFileStore();
    persistenceManager.insertObject(EVENT_REGISTRATION_ID,
    eventRegistrations, STORAGE_PADDING);
    persistenceManager.insertObject(FULL_REGISTRATION_ID,
    fullRegistrations, STORAGE_PADDING);
}

/**
 * Update event registrations in persistent storage.
 */
protected void updateEventRegistrations() {
    if (persistenceManager == null)
        return;

    System.out.println("Updating eventRegistrations");
    persistenceManager.updateObject(EVENT_REGISTRATION_ID, eventRegistrations);
}

/**
 * Update full registrations in persistent storage.
 */
protected void updateFullRegistrations() {

```

EventManagerImpl.java\_1      Mon Nov 11 16:26:42 1996      14

```

612         if (persistenceManager == null)
613             return;
614
615         System.out.println("Updating fullRegistrations");
616         persistenceManager.updateObject(FULL_REGISTRATION_ID, fullRegistrations);
617     }
618
619
620     /**
621      * Reconstruct the event notifications table from the
622      * event registrations table.
623      */
624     protected void reconstructNotifications() {
625         eventNotifications = new Hashtable();
626
627         if (persistenceManager == null)
628             return;
629
630         /*
631          * Reconstruct the eventNotifications hash table by walking
632          * the EventRegistrations hash table and extracting registrations.
633          */
634         for (Enumeration registryKeys = eventRegistrations.keys();
635              registryKeys.hasMoreElements(); ) {
636             /*
637              * For each key (event name) in the table, obtain the list of
638              * registered event queues.
639              */
640             String eventName = (String)registryKeys.nextElement();
641             System.out.println("reconstructNotifications, event = " + eventName);
642             Vector registryList = (Vector)eventRegistrations.get(eventName);
643
644             /*
645              * If no objects have registered to receive this event,
646              * remove it from the eventRegistrations hash table.
647              */
648             if ((registryList == null) || (registryList.isEmpty())) {
649                 System.out.println("reconstructNotifications, removing hash table entry for event " + eventName);
650                 eventRegistrations.remove(eventName);
651                 continue;
652             }
653
654             /*
655              * Add the event name to the eventNotifications entry of
656              * each of the registered event queues, creating hash table
657              * entries, as necessary.
658              */

```

```

EventManagerImpl.java_1      Mon Nov 11 16:26:42 1996      15

559      */
560      for (Enumeration registryElements = registryList.elements();
561           registryElements.hasMoreElements(); ) {
562          EventPost eventQueue = (EventPost)registryElements.nextElement();
563          Vector notifyList = (Vector)eventNotifications.get(eventQueue);
564          if (notifyList == null) {
565              notifyList = new Vector();
566              eventNotifications.put(eventQueue, notifyList);
567              System.out.println("reconstructNotifications, created eventNotifications hash table entry
568              )
569              notifyList.addElement(eventName);
570          }
571      }
572  }
573  }
574
575  // Misc. methods
576  /** Returns the EventManager's name */
577  protected static String getEventManagerName() {
578      return EVENT_MANAGER_NAME;
579  }
580
581  /** Returns the value of a property. */
582  protected String getProperty(String key, String def) {
583      return properties.getProperty(key, def);
584  }
585
586  // Main method
587  /**
588   * EventManagerImpl bootstrap. This is the only way to start
589   * the EventManager since it has no public constructors.
590   */
591  public static void main(String args[]) {
592      try {
593          System.setSecurityManager(new InsecurityManager());
594          EventManagerImpl eventManager = new EventManagerImpl();
595      } catch (Exception e) {
596          System.out.println("An exception occurred setting up the EventManager: " +
597                          e.getMessage());
598          e.printStackTrace();
599      }
600  }
601  }
602  }
603  }
604  }
605

```

```

EventManagerProxy.java_1      Mon Nov 11 16:26:42 1996      1      10/22/96 7:30p Noemi $

1  /* $Header: /com/meitca/hsl/zonesjagents/event/EventManagerProxy.java 1
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * A client proxy for the EventManager.
11 *
12 * SLog: /com/meitca/hsl/zonesjagents/event/EventManagerProxy.java $
13 *
14 * 1 10/22/96 7:30p Noemi
15 * EventManagerProxy is the public interface to the EventManager. It
16 * shields users from the effects of EventManager crashes.
17 */
18
19 package com.meitca.hsl.zonesjagents.event;
20
21 import java.io.*;
22
23 import java.rmi.RemoteException;
24 import java.rmi.Naming;
25 import java.rmi.Remote;
26
27
28 /**
29 * EventManagerProxy is the public interface to the EventManager. As a
30 * proxy for the Event Manager, it maintains a reference to the actual
31 * Event Manager and shields users from the effects of Event Manager
32 * crashes. Whenever the proxy fails to communicate with the Event Manager
33 * it attempts to re-establish a connection to it.
34 *
35 * @see EventManager
36 * @see EventManagerImpl
37 * @author Noemi Paciorek
38 */
39
40 public class EventManagerProxy {
41
42     // Constants
43     protected static final int DEFAULT_RETRIES = 2;
44     protected static final long DEFAULT_TIMEOUT = 10000;
45
46     // Instance variables
47

```

```

EventManagerProxy.java_1      Mon Nov 11 16:26:42 1996      2

48  /** Stub for EventManagerImpl's EventManager interface. */
49  protected EventManager eventManager;
50
51  /** Stub for EventManagerImpl's EventPost interface. */
52  protected EventPost eventPost;
53
54  /** The EventManagerImpl's name. */
55  protected String eventManagerName;
56
57  /**
58   * The number of times to retry when an invocation
59   * on the EventManager fails.
60   */
61  int retries;
62
63  /** The timeout period in ms. for requests to the EventManager. */
64  long timeout;
65
66  // Constructors
67  /**
68   * Constructs an EventManagerProxy.
69   */
70
71  public EventManagerProxy()
72  throws Exception {
73
74      this(DEFAULT_RETRIES, DEFAULT_TIMEOUT);
75  }
76
77  /**
78   * Constructs an EventManagerProxy.
79   * @param retries The number of times to retry if an operation fails.
80   */
81
82  public EventManagerProxy(int retries)
83  throws Exception {
84
85      this(retries, DEFAULT_TIMEOUT);
86  }
87
88  /**
89   * Constructs an EventManagerProxy.
90   * @param timeout The time to wait in ms. between retries.
91   */
92
93  public EventManagerProxy(long timeout)
94  throws Exception {

```

EventManagerProxy.java\_1      Mon Nov 11 16:26:42 1996      3

```

95         this(DEFAULT_RETRIES, timeout);
96     }
97
98
99
100     /**
101     * Constructs an EventManagerProxy.
102     * @param retries The number of times to retry if an operation fails.
103     * @param timeout The time to wait in ms. between retries.
104     */
105     public EventManagerProxy(int retries, long timeout)
106     throws Exception {
107
108         this.retries = (retries >= 0) ? retries : DEFAULT_RETRIES;
109         this.timeout = (timeout > 0) ? timeout : DEFAULT_TIMEOUT;
110
111         /*
112         * Lookup the EventManager.
113         */
114         initialize();
115     }
116
117
118     // Instance methods
119     /**
120     * Lookup the Event Manager in the RMI registry and obtain a
121     * stub for its EventManager and EventPost interfaces.
122     */
123     private void initialize()
124     throws Exception {
125
126         eventManagerName = EventManagerImpl.getEventManagerName();
127         try {
128             Remote stub = Naming.lookup(eventManagerName);
129             eventManager = (EventManager) stub;
130             eventPost = (EventPost) stub;
131         } catch (Exception e) {
132             System.out.println("initialize: error looking up EventManager: "
133                 + e.getMessage());
134             e.printStackTrace();
135             throw e;
136         }
137     }
138
139
140     /**
141     * Block for the timeout interval. Then look up the

```

EventManagerProxy.java\_1      Mon Nov 11 16:26:42 1996      4

```

142  * EventManager.
143  */
144  private void waitAndInitialize()
145  throws Exception {
146
147      synchronized(this) {
148          try {
149              this.wait(timeout);
150          } catch (InterruptedException e) { }
151      }
152      initialize();
153  }
154
155  /*
156  * Convert the event class names to strings.
157  */
158  private String[] eventNameToString(EventType[] events) {
159
160      int length = events.length;
161      String eventNames[] = new String[length];
162      for (int i = 0; i < length; i++) {
163          eventNames[i] = events[i].getClass().getName();
164          System.out.println("eventNameToString, event = " + eventNames[i]);
165      }
166      return eventNames;
167  }
168
169
170
171  // Methods to handle registrations.
172
173  /**
174  * Register interest in receiving specified events.
175  * @param events    An array of events an object is interested in receiving.
176  * @param eventQueue The associated event queue's EventPost interface.
177  * @exception RemoteException If an error occurs setting up network
178  * connections.
179  * @exception IOException If the transport layer generates one.
180  */
181  public void registerEvents(EventType events[], EventPost eventQueue)
182  throws Exception {
183
184      /*
185      * Convert the event class names to strings.
186      * Then invoke the EventManager's registerEvents
187      * method and retry the operation, if necessary.
188      */

```

```

EventManagerProxy.java_1      Mon Nov 11 16:26:42 1996      5

189 String eventNames[] = eventNamesToString(events);
190 for (int i = 0; i <= retries; i++) {
191     try {
192         eventManager.registerEvents(eventNames, eventQueue);
193         return;
194     } catch (RemoteException e1) {
195         if (i == retries) {
196             System.out.println("registerEvents: Throwing RemoteException");
197             throw e1;
198         }
199         System.out.println("registerEvents: Caught RemoteException");
200     } catch (IOException e2) {
201         if (i == retries) {
202             System.out.println("registerEvents: Throwing IOException");
203             throw e2;
204         }
205         System.out.println("registerEvents: Caught IOException");
206     }
207 }
208 /* Block for the timeout interval. Then lock up the
209    * EventManager, before retrying the operation.
210    */
211 waitAndInitialize();
212
213 }
214
215 /**
216    * Register interest in receiving all events posted to this EventManager.
217    * @param eventQueue The associated event queue's EventPost interface.
218    * @exception RemoteException If an error occurs setting up network
219    * connections.
220    * @exception IOException If the transport layer generates one.
221    */
222 public void registerAll(EventPost eventQueue)
223     throws Exception {
224
225     /*
226     * Invoke the EventManager's registerAll
227     * method and retry the operation, if necessary.
228     */
229     for (int i = 0; i <= retries; i++) {
230         try {
231             eventManager.registerAll(eventQueue);
232             return;
233         } catch (RemoteException e1) {
234             if (i == retries) {
235

```



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```

EventManagerProxy.java_1      Mon Nov 11 16:26:42 1996      6

236     System.out.println("registerAll: Throwing RemoteException");
237     throw e1;
238 }
239     System.out.println("registerAll: Caught RemoteException");
240     } catch (IOException e2) {
241         if (i == retries) {
242             System.out.println("registerAll: Throwing IOException");
243             throw e2;
244         }
245         System.out.println("registerAll: Caught IOException");
246     }
247     /*
248     * Block for the timeout interval. Then look up the
249     * EventManager, before retrying the operation.
250     */
251     waitAndInitialize();
252 }
253
254 // Methods to unregister events.
255 /**
256  * Remove registration for specified events.
257  * @param events An array of events an object is interested in receiving.
258  * @param eventQueue The associated event queue's EventPost interface.
259  * @exception RemoteException If an error occurs setting up network
260  * connections.
261  * @exception EventManagerException If the event queue was not registered
262  * for one or more of the specified exceptions.
263  * @exception IOException If the transport layer generates one.
264  */
265     public void unregisterEvents(EventType events[], EventPost eventQueue)
266         throws Exception {
267
268     /*
269     * Convert the event class names to strings.
270     * Then invoke the EventManager's registerEvents
271     * method and retry the operation, if necessary.
272     */
273     String eventNames[] = eventNamesToString(events);
274     for (int i = 0; i <= retries; i++) {
275         try {
276             eventManager.unregisterEvents(eventNames, eventQueue);
277             return;
278         } catch (RemoteException e1) {
279             if (i == retries) {
280                 System.out.println("unregisterEvents: Throwing RemoteException");
281             }
282         }

```

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```

EventManagerProxy.java_1      Mon Nov 11 16:26:42 1996      7

283         throw e1;
284     }
285     System.out.println("unregisterEvents: Caught RemoteException");
286     } catch (IOException e2) {
287         if (i == retries) {
288             System.out.println("unregisterEvents: Throwing IOException");
289             throw e2;
290         }
291         System.out.println("unregisterEvents: Caught IOException");
292     }
293     /*
294      * Block for the timeout interval. Then look up the
295      * EventManager, before retrying the operation.
296      */
297     waitAndInitialize();
298 }
299
300
301
302 /**
303  * Remove registration for all events.
304  * @param eventQueue The associated event queue's EventPost interface.
305  * This method is often called by finalizers, so it does not
306  * propagate any errors.
307  */
308 public void unregisterAll(EventPost eventQueue) {
309     /*
310      * Invoke the EventManager's registerAll
311      * method and retry the operation, if necessary.
312      */
313     for (int i = 0; i <= retries; i++) {
314         try {
315             eventManager.unregisterAll(eventQueue);
316             return;
317         } catch (RemoteException e1) {
318             System.out.println("unregisterAll: Caught RemoteException");
319         } catch (IOException e2) {
320             System.out.println("unregisterAll: Caught IOException");
321         }
322     }
323     /*
324      * Block for the timeout interval. Then look up the
325      * EventManager, before retrying the operation.
326      */
327     try {
328         waitAndInitialize();
329     } catch (Exception e3) {
330         System.out.println("waitAndInitialize failed");
331     }

```

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EventManagerProxy.java\_1 Mon Nov 11 16:26:42 1996 8

```

330     }
331   )
332 }
333
334 // Methods to post events.
335
336 /**
337  * Event notification interface.
338  * @param event The event to post.
339  * @exception RemoteException If an error occurs setting up network
340  * connections.
341  * @exception EventException If an error occurs posting the event.
342  * @exception IOException If the transport layer generates one.
343  */
344 public void postEvent(EventType event)
345     throws Exception {
346     /*
347     * Invoke the EventManager's eventPost
348     * method and retry the operation, if necessary.
349     */
350     for (int i = 0; i <= retries; i++) {
351         try {
352             eventPost.postEvent(event);
353             return;
354         } catch (RemoteException e1) {
355             if (i == retries) {
356                 System.out.println("postEvent: Throwing RemoteException");
357                 throw e1;
358             }
359             System.out.println("postEvent: Caught RemoteException");
360         } catch (IOException e2) {
361             if (i == retries) {
362                 System.out.println("postEvent: Throwing IOException");
363                 throw e2;
364             }
365             System.out.println("postEvent: Caught IOException");
366         }
367     }
368     /*
369     * Block for the timeout interval. Then look up the
370     * EventManager, before retrying the operation.
371     */
372     waitAndInitialize();
373 }
374 }
375 }
376

```

9

Mon Nov 11 16:26:42 1996

EventManagerProxy.java\_1

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```

EventPost.java_1      Mon Nov 11 16:36:42 1996      1
1  /* $Header: /com/meitca/hsl/zonesjagents/event/EventPost.java 2 10/22/96 7:10p Noemi $
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * Interface for event notification
11  *
12  * $Log: /com/meitca/hsl/zonesjagents/event/EventPost.java $
13  *
14  * 2 10/22/96 7:10p Noemi
15  * Changed the throws clause of the postEvent method.
16  *
17  * 1 10/14/96 6:57p Noemi
18  * Interface used for posting events.
19  */
20
21 package com.meitca.hsl.zonesjagents.event;
22
23 import java.io.*;
24
25 import java.rmi.Remote;
26 import java.rmi.RemoteException;
27
28 /**
29  * EventPost is a distributed RMI interface for notification of events.
30  *
31  * @author Noemi Paciorek
32  */
33
34 public interface EventPost
35     extends Remote {
36
37     // Instance methods.
38     /**
39      * Event notification interface.
40      * @param event The event to post.
41      * @exception RemoteException If an error occurs setting up network
42      * connections.
43      * @exception EventException If an error occurs posting the event.
44      */
45     public void postEvent(EventType event)
46         throws RemoteException, EventException, IOException;
47

```

2

Mon Nov 11 15:25:42 1996

EventPost.java\_1

48 }

```

EventQueueImpl.java_1      Mon Nov 11 16:26:42 1996      1      10/14/96 6:58p Noemi $

1  /* $Header: /com/meitca/hsl/zonesjagents/event/EventQueueImpl.java 1
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Event queue distributed object.
11 *
12 * SLog: /com/meitca/hsl/zonesjagents/event/EventQueueImpl.java $
13 *
14 * 1      10/14/96 6:58p Noemi
15 * Event queue implementation.
16 */
17
18 package com.meitca.hsl.zonesjagents.event;
19
20 import java.util.*;
21
22 import java.rmi.server.UnicastRemoteServer;
23 import java.rmi.RemoteException;
24 import java.rmi.Naming;
25 import java.rmi.NotSupportedException;
26
27 /**
28 * EventQueueImpl is an event queue that implements the RMI
29 * EventPost interface.
30 *
31 * Event notification is performed by appending an event to the queue.
32 * Each queue has an associated EventQueueThread started by the constructor.
33 * The thread dequeues events and calls their handlers.
34 *
35 * @see EventQueueThread
36 * @see EventPost
37 * @author Noemi Paciorek
38 */
39
40 public class EventQueueImpl
41 extends UnicastRemoteServer
42 implements EventPost {
43
44     // Instance variables
45     /** The event queue */
46     protected Vector eventQueue;
47

```

```

EventQueueImpl.java_1      Mon Nov 11 16:26:42 1996      2

48  /** The thread that manages this queue */
49  protected EventQueueThread queueThread;
50
51  // Constructors
52  /**
53   * Protected Default Constructor for EventQueueImpl.
54   * @exception  IllegalArgumentException  Whenever called.
55   */
56  protected EventQueueImpl()
57  throws RemoteException,  IllegalAccessException {
58
59      System.out.println("Default constructor called for EventQueueImpl");
60      throw new IllegalArgumentException("EventQueueImpl default constructor");
61  }
62
63  /**
64   * Constructs an EventQueueImpl
65   * @param  handler An EventHandler interface.
66   */
67  public EventQueueImpl(EventHandler handler)
68  throws RemoteException {
69      eventQueue = new Vector();
70      queueThread = new EventQueueThread(this, handler);
71      ..
72
73  /**
74   * Constructs an EventQueueImpl
75   * @param  handler An EventHandler interface.
76   * @param  timeout The time in ms to wait between consecutive queue
77   *              examinations.
78   */
79  public EventQueueImpl(EventHandler handler, long timeout)
80  throws RemoteException {
81      eventQueue = new Vector();
82      queueThread = new EventQueueThread(this, handler, timeout);
83  }
84
85  // Instance methods
86  /**
87   * Posts an event by enqueueing it and waking up the
88   * queue's thread.
89   * @param  event  The event to post.
90   */
91  public synchronized void postEvent(EventType event) {
92      System.out.println("EventQueueImpl, posting event");
93      enqueue(event);
94      this.notifyAll();

```



EventQueueImpl.java\_1      Mon Nov 11 16:26:42 1996      3

```
95     )
96
97     /**
98     * Enqueues an event.
99     * @param event The event to queue.
100    */
101    protected final synchronized void enqueue(EventType event) {
102        eventQueue.addElement(event);
103    }
104
105    /**
106    * Dequeues an event.
107    * @return The first event in the queue.
108    */
109    protected final synchronized EventType dequeue()
110        throws ArrayIndexOutOfBoundsException {
111        if (!eventQueue.isEmpty()) {
112            EventType event = (EventType) eventQueue.firstElement();
113            eventQueue.removeElementAt(0);
114            return event;
115        }
116        return null;
117    }
118
119    )
120
121
122
123
124
125
126
127
```

```

EventQueueThread.java_1      Mon Nov 11 16:26:42 1996      1      10/14/96 6:59p Noemi $

1  /* $Header: /com/meitca/hsl/zonesjagents/event/EventQueueThread.java 1
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Thread that manages an event queue.
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/event/EventQueueThread.java $
13 *
14 * 1 10/14/96 6:59p Noemi
15 * Thread to manage the event queue.
16 */
17
18 package com.meitca.hsl.zonesjagents.event;
19
20 /**
21 * EventQueueThread is a Thread that manages an event queue.
22 * Event notification is implemented by appending an event to the queue
23 * and waking up its EventQueueThread to process the event by calling its
24 * event handler.
25 * The EventQueueThread is instantiated by the EventQueueImpl constructor.
26 */
27 * @see EventQueueImpl
28 * @see EventPost
29 * @see EventHandler
30 * @author Noemi Paciorek
31 */
32 class EventQueueThread
33 extends Thread {
34
35     // Constants
36     /** The default timeout value in ms. */
37     public static final long DEFAULT_TIMEOUT = 1000;
38
39     // Instance variables
40     /** This thread's event queue */
41     protected EventQueueImpl eventQueue;
42
43     /** The application's event handler */
44     protected EventHandler eventHandler;
45
46     /** The time in ms between consecutive examinations of the queue. */
47     protected long timeout;

```

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EventQueueThread.java\_1 Mon Nov 11 16:26:42 1996 2

```

48 // Constructors
49 /**
50  * Protected Default Constructor for an EventQueueThread.
51  * @exception IllegalAccessException Whenever called.
52  */
53 protected EventQueueThread(
54     throws IllegalAccessException {
55
56     System.out.println("Default constructor called for EventQueueThread");
57     throw new IllegalAccessException("EventQueueThread default constructor");
58 }
59
60 /** Constructs an EventQueueThread.
61  * @param queue The associated event queue.
62  * @param handler The associated event handler interface.
63  */
64 public EventQueueThread(EventQueueImpl queue, EventHandler handler) {
65     this(queue, handler, DEF?ULT_TIMEOUT);
66 }
67
68 /** Constructs an EventQueueThread.
69  * @param queue The associated event queue.
70  * @param handler The associated event handler interface.
71  * @param timeout The time in ms to wait-between consecutive queue
72  *     examinations.
73  */
74 public EventQueueThread(EventQueueImpl queue, EventHandler handler, long timeout) {
75     eventQueue = queue;
76     eventHandler = handler;
77     this.timeout = timeout;
78     this.start();
79 }
80
81 // Instance methods
82
83 /**
84  * The thread's run method.
85  */
86 public void run() {
87     while (true) {
88         try {
89             synchronized(eventQueue) {
90                 eventQueue.wait(timeout);
91             }
92         } catch (InterruptedException e) { }
93     }
94 }

```

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```
EventQueueThread.java_1      Mon Nov 11 16:26:42 1996      3

    EventType event;
    while ((event = eventQueue.dequeue()) != null) {
        System.out.println("EventQueueThread, handling event");
        try {
            eventHandler.handleEvent(event);
        } catch (Exception ex) {
            System.out.println("EventQueueThread: can't handle event: " +
                               ex.getMessage());
            ex.printStackTrace();
        }
    }
}
```

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```

EventType.java_1      Mon Nov 11 16:23:43 1996      1
1 /* $Header: /com/meitca/hsl/zonesjagents/event/EventType.java 1 10/14/96 6:55p Noemi S
2 *
3 * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4 * Information Technology Center America.
5 * All rights reserved.
6 *
7 * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8 *
9 * DESCRIPTION
10 * Base class for distributed events.
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/event/EventType.java $
13 * 1 10/14/96 6:55p Noemi
14 * Base class for distributed events.
15 *
16 */
17 package com.meitca.hsl.zonesjagents.event;
18
19 import com.meitca.hsl.util.UniqueID;
20
21 /**
22 * Base class for distributed events. EventType describes an event.
23 * It contains: a unique ID (generated by the EventManager) and a description
24 * (optionally passed to the constructors).
25 *
26 * Applications must derive and handle their own event types.
27 *
28 * @author Noemi Paciorek
29 *
30 */
31 abstract public class EventType {
32
33     // Constants
34     private static final String UNKNOWN = "Unknown";
35     private static final String TYPE = "event";
36
37     // Instance variables
38     /** A unique ID representing the event */
39     protected String eventID;
40
41     /** A description of the event */
42     protected String description;
43
44     // Constructors
45     /** Constructs an EventType */

```

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```

EventType.java_1      Mon Nov 11 16:26:43 1996      2

48 public EventType() {
49     this(UNKNOWN);
50 }
51
52 /** Constructs an EventType
53  * @param description A String describing the event.
54  */
55 public EventType(String description) {
56     eventId = UniqueID.getNextID(TYPE, this);
57     System.out.println("eventId = " + eventId);
58     this.description = description;
59 }
60
61 // Instance methods
62 /**
63  * String representation of event.
64  * @return A String representation of the event.
65  */
66 public final String toString() {
67     return (eventId + "/" + description);
68 }
69
70 /**
71  * Retrieve an event's ID.
72  * @return The event's ID
73  */
74 public final String getEventID() {
75     return eventId;
76 }
77
78 /**
79  * Retrieve an event's description.
80  * @return A description of the event.
81  */
82 public final String getEventDescription() {
83     return description;
84 }
85
86
87 )
88
89
90
91
92
93
94

```

3

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EventType.java\_1

95  
96  
97  
98

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```

1  Mon Nov 11 16:23:18 1996      1      10/22/96 7:32p Noemi $
2  /* $Header: /com/meitca/hsl/zonesjagents/shared/PersistentStoreHandler.java 1
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10 * Persistent Store Manager wrapper that handles exceptions.
11 *
12 * $Log: /com/meitca/hsl/zonesjagents/shared/PersistentStoreHandler.java $
13 *
14 * 1 10/22/96 7:32p Noemi
15 * A generic wrapper for PersistentStoreManager that catches exceptions
16 * and retries operations, as necessary.
17 */
18 package com.meitca.hsl.zonesjagents.shared;
19
20 import com.meitca.hsl.zonesjagents.persistence.*;
21
22 /**
23 * A wrapper class for the persistent storage manager
24 * (persistence.PersistentStoreManager) that catches
25 * all its exceptions and performs the appropriate cleanup.
26 * @see PersistentStoreManager
27 * @author Noemi Paciorek
28 */
29 public class PersistentStoreHandler {
30
31     // Instance variables
32     /** A reference to the persistent store manager. */
33     protected PersistentStoreManager persistenceManager;
34
35     // Constructors
36     /**
37      * Constructs a PersistentStoreHandler.
38      * @param filename The name of the persistent storage file.
39      */
40     public PersistentStoreHandler(String filename) {
41         try {
42             persistenceManager = new PersistentStoreManager(filename);
43         } catch (PersistentStoreException e) {
44             System.out.println("PersistentStoreHandler: can't create persistent store manager * + e.getMessage()");
45             e.printStackTrace();
46             persistenceManager = null;
47         }
48     }
49 }

```



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```

48     )
49     )
50
51     // Finalizer
52     /**
53      * Deletes reference to PersistentStoreManager.
54      */
55     protected void finalize()
56     throws Throwable {
57         System.out.println("PersistentStoreHandler Finalizer called");
58
59         // Delete reference to Persistent Store Manager.
60         persistenceManager = null;
61
62         super.finalize();
63     }
64
65
66
67
68     // Instance methods.
69     /**
70      * Find an object in the persist store.
71      * @param object The Object to locate.
72      * @return The Object's persistent storage ID.
73      */
74     public int findObject(Object object) {
75         return persistenceManager.findObject(object);
76     }
77
78     /**
79      * Insert an Object into persistent storage.
80      * * If a storage manager exception occurs, attempt to
81      * * truncate the persistent storage and disable persistence.
82      * * @param object The Object represented by id.
83      * * @return The Object's persistent storage ID.
84      * * A return value of PersistentStoreManager.INVALID_OID indicates
85      * * an unsuccessful attempt to insert the object.
86      */
87     public int insertObject(Object object) {
88         return insertObject(0, object, 0);
89     }
90
91
92     /**
93      * Insert an Object into persistent storage.
94      * * If a storage manager exception occurs, attempt to

```

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```

95  * truncate the persistent storage and disable persistence.
96  * @param Object The Object represented by id.
97  * @param space The additional space in bytes to be preallocated
98  * for this object.
99  * @return The Object's persistent storage ID.
100  * A return value of PersistentStoreManager.INVALID_OID indicates
101  * an unsuccessful attempt to insert the object.
102  */
103  public int insertObject(Object object, int space) {
104      return insertObject(0, object, space);
105  }
106
107
108  /**
109   * Insert an Object into persistent storage.
110   * If a storage manager exception occurs, attempt to
111   * truncate the persistent storage and disable persistence.
112   * @param id The Object's persistent storage ID.
113   * @param Object The Object represented by id.
114   * @return The Object's persistent storage ID.
115   * A return value of PersistentStoreManager.INVALID_OID indicates
116   * an unsuccessful attempt to insert the object.
117  */
118  public int insertObject(int id, Object object) {
119      return insertObject(id, object, 0);
120  }
121
122
123  /**
124   * Insert an Object into persistent storage.
125   * If a storage manager exception occurs, attempt to
126   * truncate the persistent storage and disable persistence.
127   * @param id The Object's persistent storage ID.
128   * @param Object The Object represented by id.
129   * @param space The additional space in bytes to be preallocated
130   * for this object.
131   * A return value of PersistentStoreManager.INVALID_OID indicates
132   * an unsuccessful attempt to insert the object.
133  */
134  public int insertObject(int id, Object object, int space) {
135      if (persistentManager == null)
136          return PersistentStoreManager.INVALID_OID;
137
138      try {
139          if (id == 0)
140              return persistentManager.insertObject(object, space);
141          return persistentManager.insertObject(id, object, space);

```

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```

142     ) catch (PersistentStoreDuplicateObjectException e1) {
143         try {
144             id = persistenceManager.findObject(object);
145             if (id != PersistentStoreManager.INVALID_OID) {
146                 persistenceManager.updateObject(id, object);
147                 return id;
148             }
149         } catch (PersistentStoreException e2) {
150             System.out.println("insertObject: duplicate object found" + e2.getMessage());
151             e2.printStackTrace();
152             truncateFileStore();
153             persistenceManager = null;
154         }
155     } catch (PersistentStoreInvalidObjectException e3) {
156         System.out.println("insertObject: invalid ID" + e3.getMessage());
157         e3.printStackTrace();
158     } catch (PersistentStoreException e4) {
159         System.out.println("insertObject: can't insert object " + e4.getMessage());
160         e4.printStackTrace();
161         truncateFileStore();
162         persistenceManager = null;
163     }
164     return PersistenceStoreManager.INVALID_OID;
165 }
166
167 /**
168  * Fetch an Object from persistent storage.
169  * If a storage manager exception occurs, attempt to
170  * truncate the persistent storage and disable persistence.
171  * @param id The Object's persistent storage ID.
172  * @return Object The Object represented by id, or null,
173  * if the Object was not found in persistent storage.
174 */
175 public Object fetchObject(int id) {
176     if (persistenceManager == null)
177         return null;
178
179     try {
180         return persistenceManager.fetchObject(id);
181     } catch (PersistentStoreObjectNotFoundException e1) {
182         System.out.println("fetchObject: Object not found in persistent store, ID = " + id);
183     } catch (PersistentStoreInvalidObjectException e2) {
184         System.out.println("fetchObject: invalid ID" + e2.getMessage());
185         e2.printStackTrace();
186     } catch (PersistentStoreException e3) {
187         System.out.println("fetchObject: can't fetch object " + e3.getMessage());
188     }

```

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```

189 e3.printStackTrace();
190 truncateFileStore();
191 persistenceManager = null;
192 }
193 return null;
194 )
195
196
197 /**
198  * Update an Object in persistent storage.
199  * If a storage manager exception occurs, attempt to
200  * truncate the persistent storage and disable persistence.
201  * @param id The Object's persistent storage ID.
202  * @param Object The updated Object represented by id.
203  * @return A boolean indicating if the update was successful.
204  */
205 public boolean updateObject(int id, Object object) {
206     if (persistenceManager == null)
207         return false;
208
209     try {
210         persistenceManager.updateObject(id, object);
211         return true;
212     } catch (PersistentStoreObjectNotFoundException e1) {
213         System.out.println("updateObject: Object not found in persistent store, ID = " + id);
214         try {
215             persistenceManager.insertObject(id, object);
216             return true;
217         } catch (PersistentStoreException e2) {
218             System.out.println("updateObject: can't insert object " + e2.getMessage());
219             e2.printStackTrace();
220             truncateFileStore();
221             persistenceManager = null;
222         }
223     } catch (PersistentStoreInvalidObjectException e3) {
224         System.out.println("updateObject: invalid ID" + e3.getMessage());
225         e3.printStackTrace();
226     } catch (PersistentStoreException e4) {
227         System.out.println("updateObject: can't update object " + e4.getMessage());
228         e4.printStackTrace();
229         truncateFileStore();
230         persistenceManager = null;
231     }
232     return false;
233 }
234
235

```

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```
283     try {
284         persistenceManager.truncateFileStore();
285         return true;
286     } catch (Exception e) {
287         System.out.println("truncateFileStore: can't truncate store " + e.getMessage());
288         e.printStackTrace();
289         persistenceManager = null;
290         return false;
291     }
292 )
293
294 /**
295  * Return a reference to the persistent storage manager.
296  */
297 public PersistentStoreManager getPersistenceManager() {
298     return persistenceManager;
299 }
300 )
301
302
303
304
```

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```

236 /**
237  * Delete an object from persistent storage.
238  * If a storage manager exception occurs, attempt to
239  * truncate the persistent storage and disable persistence.
240  * @param id The Object's persistent storage ID.
241  * @return A boolean indicating if the deletion was successful.
242  */
243 public boolean deleteObject(int id) {
244     if (persistenceManager == null)
245         return false;
246
247     try {
248         persistenceManager.deleteObject(id);
249         return true;
250     } catch (PersistentStoreObjectNotFoundException e1) {
251         System.out.println("deleteObject: Object not found in persistent store, ID = " + id);
252     } catch (PersistentStoreInvalidObjectException e2) {
253         System.out.println("deleteObject: invalid ID" + e2.getMessage());
254         e2.printStackTrace();
255     } catch (PersistentStoreException e3) {
256         System.out.println("deleteObject: can't delete object " + e3.getMessage());
257         e3.printStackTrace();
258         truncateFileStore();
259         persistenceManager = null;
260     }
261     return false;
262 }
263
264
265 /**
266  * Disable storage of objects in persistent store. This method
267  * also truncates the persistent storage file to 0 bytes.
268  */
269 public void disablePersistence() {
270     truncateFileStore();
271     persistenceManager = null;
272 }
273
274
275 /**
276  * Truncate the persistent storage file to 0 bytes. If a storage manager
277  * exception occurs, disable persistence.
278  */
279 public boolean truncateFileStore() {
280     if (persistenceManager == null)
281         return false;
282

```

```

1  /* $Header: /com/meitca/hsl/util/UniqueID.java 1 10/15/96 7:20a Billp $
2  *
3  * Copyright 1996 Horizon Systems Laboratory, Mitsubishi Electric
4  * Information Technology Center America.
5  * All rights reserved.
6  *
7  * CONFIDENTIAL AND PROPRIETARY PROPERTY OF MITSUBISHI ELECTRIC ITA.
8  *
9  * DESCRIPTION
10  * This class generates IDs that are unique across distributed systems.
11  * $Log: /com/meitca/hsl/util/UniqueID.java $
12  *
13  * 1 10/15/96 7:20a Billp
14  */
15
16 package com.meitca.hsl.util;
17
18 import java.util.*;
19
20 import java.net.InetAddress;
21
22 /**
23  * This class generates IDs that are unique within a Java VM.
24  * It is used by classes that need to generate unique IDs.
25  *
26  * @author Noemi Paciorek
27  */
28 public class UniqueID {
29
30     // Class variables
31     /** A counter used in generating IDs. */
32     protected static long IDNum = 0;
33
34     /** A unique ID representing the host */
35     protected static String host;
36
37     // Static initializer
38     static {
39         /**
40          * Try to obtain the host's name and IP address. If this fails,
41          * construct a pseudo-random name and hope for the best! (Of course,
42          * this should never happen.)
43          */
44         try {
45             host = InetAddress.getLocalHost().toString();
46         } catch (Exception e) {
47             host = "__HOST_ID_" + new Random().nextLong();

```

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```

48     )
49
50
51
52 // Constructors
53 // No accessible constructors.
54 /**
55  * Protected Default Constructor for UniqueID.
56  * This class never needs to be instantiated since all its variables
57  * and methods are static.
58  * @exception IllegalAccessException Whenever called.
59  */
60 protected UniqueID()
61     throws IllegalAccessException {
62
63     System.out.println("Default constructor called for UniqueID");
64     throw new IllegalAccessException("UniqueID default constructor");
65 }
66
67
68 // Class methods
69 /**
70  * This method attempts to create an ID that is unique across
71  * Java VMs. The ID is created from: the hostname, an application type
72  * (e.g., agent), the current time in ms, and the virtual memory
73  * address of the object being created.
74  * @param type A String containing an application type, e.g., "agent".
75  * @param object The "this" reference of the calling object.
76  */
77 public static String getNextID(String type, Object object) {
78     return (host + "/" + type + nextIDNum() + "/" +
79             System.currentTimeMillis() + Integer.toHexString(object.hashCode()));
80 }
81
82
83
84 private static final synchronized long nextIDNum() {
85     return ++IDNum;
86 }
87
88 )

```



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## CLAIMS

What is claimed is:

5 1. In a computer network including at least a first computer and a second computer, an apparatus for performing a task in a second computer, comprising:

a routine that generates a mobile agent object in the first computer, the mobile agent including both data and executable code;

10 a protocol for transmission of the mobile agent from the first computer to the second computer, wherein execution of the mobile agent in the second computer following such transmission prompts the task to be performed in the second computer; and

15 an itinerary containing a reference to each destination computer to which the mobile agent is designated to migrate and a reference to a method associated with each respective destination computer reference, the respective method being invoked when the mobile agent is present on the respective destination computer.

20 2. The apparatus of claim 1 wherein the transmission protocol includes a routine in the first computer for serializing the mobile agent to generate a stream of data therefrom.

25 3. The apparatus of claim 2 wherein the transmission protocol includes a routine in the second computer for deserializing the stream of bytes to regenerate the mobile agent therefrom.

30 4. The apparatus of claim 1 wherein the task is data gathering, and wherein the mobile agent is transmitted back to the first computer from the second computer following completion of such data gathering.

35 5. The apparatus of claim 1 wherein the mobile agent

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migrates to a plurality of destination computers within the computer network.

5        6.    The apparatus of claim 1 wherein at least one destination computer reference is a Uniform Resource Locator.

10       7.    The apparatus of claim 1 wherein at least a portion of the executable code required for invoking the method is retrieved from a mobile codebase portion of the executable code included in the mobile agent.

15       8.    The apparatus of claim 7 wherein the mobile agent includes a reference to a home codebase located on the first computer, the reference being employed to retrieve required executable code which is not present in the mobile codebase.

20       9.    The apparatus of claim 8 wherein required executable code is sought first in the computer on which the mobile agent is executing, then in the mobile codebase, and finally on the home codebase.

25       10.   The apparatus of claim 8 wherein a new thread is formed for execution of the mobile agent in the destination computer following receipt of the mobile agent, and wherein a security feature prevents the mobile agent from operating outside a scope assigned to such thread.

30       11.   The apparatus of claim 8 wherein the mobile agent further includes sub-objects.

35       12.   The apparatus of claim 1 wherein a persistent local copy of the mobile agent is stored following receipt of the mobile agent, and wherein such copy is overwritten with an updated persistent copy following agent execution.

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13. In a computer network including at least a first computer and a second computer, a method for performing a task in a second computer, comprising the steps of:

generating a mobile agent object in the first computer,  
5 the mobile agent including both data and executable code;

transmitting the mobile agent from the first computer  
to the second computer;

receiving the mobile agent in the second computer; and

10 executing the mobile agent in the second computer in  
accordance with an itinerary which contains a reference to  
each destination computer to which the mobile agent is  
designated to migrate and a reference to a method associated  
with each respective destination computer reference, the  
method associated with the second computer being invoked when  
15 the mobile agent is present on the second computer.

14. The method of claim 13 including the further step of  
serializing the mobile agent to generate a stream of data  
therefrom in the first computer.

20

15. The method of claim 14 including the further step of  
deserializing the stream of bytes to regenerate the mobile  
agent therefrom in the second computer.

25

16. The method of claim 13 wherein the task is data  
gathering, and including the further step of transmitting the  
mobile agent back to the first computer from the second  
computer following completion of such data gathering.

30

17. The method of claim 13 including the further step of  
causing the mobile agent to sequentially migrate to a  
plurality of destination computers within the computer  
network.

35

18. The method of claim 13 including the further step of  
employing a Uniform Resource Locator as one of the at least  
one destination computer reference.

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19. The method of claim 13 including the further step of retrieving at least a portion of the executable code required for invoking the method from a mobile codebase portion of the executable code included in the mobile agent.

5 20. The method of claim 19 wherein the mobile agent includes a reference to a home codebase located on the first computer, and including the further step of employing the reference to retrieve required executable code which is not present in the  
10 mobile codebase.

21. The method of claim 20 including the further step of searching for required executable code first in the computer on which the mobile agent is executing, then in the mobile  
15 codebase, and finally on the home codebase.

22. The method of claim 21 including the further step of forming a new thread in the destination computer for execution of the mobile agent following receipt thereof, and  
20 wherein a security feature prevents the mobile agent from operating outside a scope assigned to such thread.

23. The method of claim 21 including the further step of inserting sub-objects into the mobile agent.

24. The method of claim 13 including the further step of storing a persistent local copy of the mobile agent following receipt thereof, and overwriting such copy with an updated  
30 persistent copy following agent execution.

25. In a computer network including at least a first computer and a second computer, an apparatus for performing a task in a second computer, comprising:

35 a routine that generates a mobile agent object in the first computer, the mobile agent including both data and executable code;

a protocol for transmission of the mobile agent from the first computer to the second computer, wherein execution of

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the mobile agent in the second computer following such transmission prompts the task to be performed in the second computer, at least a portion of the executable code required for execution being retrieved from a mobile codebase portion of the executable code included in the mobile agent; and

a reference to a home codebase located on the first computer, the reference being employed to retrieve required executable code which is not present in the mobile codebase.

26. The apparatus of claim 25 wherein the transmission protocol includes a routine in the first computer for serializing the mobile agent to generate a stream of data therefrom.

27. The apparatus of claim 26 wherein the transmission protocol includes a routine in the second computer for deserializing the stream of bytes to regenerate the mobile agent therefrom.

28. The apparatus of claim 25 wherein the task is data gathering, and wherein the mobile agent is transmitted back to the first computer from the second computer following completion of such data gathering.

29. The apparatus of claim 25 wherein the mobile agent migrates to a plurality of destination computers within the computer network.

30. The apparatus of claim 29 wherein the mobile agent further includes an itinerary containing a reference to each destination computer to which the agent is designated to migrate and a reference to a method associated with each respective destination computer reference, the respective method being invoked when the mobile agent is present on the respective destination computer.

31. The apparatus of claim 30 wherein at least one destination computer reference is a Uniform Resource Locator.

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32. The apparatus of claim 25 wherein required executable code is sought first in the computer on which the mobile agent is executing, then in the mobile codebase, and finally on the home codebase.

33. The apparatus of claim 25 wherein a new thread is formed for execution of the mobile agent in the destination computer following receipt of the mobile agent, and wherein a security feature prevents the mobile agent from operating outside a scope assigned to such thread.

34. The apparatus of claim 25 wherein the mobile agent further includes sub-objects.

35. The apparatus of claim 30 wherein a persistent local copy of the mobile agent is stored following receipt of the mobile agent, and wherein such copy is overwritten with an updated persistent copy following agent execution.

36. In a computer network including at least a first computer and a second computer, a method for performing a task in a second computer, comprising the steps of:

generating a mobile agent object in the first computer,  
the mobile agent including both data and executable code;  
transmitting the mobile agent from the first computer to the second computer;

receiving the mobile agent in the second computer;  
retrieving at least a portion of the executable code required for invoking the method from a mobile codebase portion of the executable code included in the mobile agent;  
employing a reference to a home codebase located on the first computer to retrieve required executable code which is not present in the mobile codebase; and

executing the mobile agent in the second computer such that the mobile agent prompts the task to be performed in the second computer.

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37. The method of claim 36 including the further step of serializing the mobile agent to generate a stream of data therefrom in the first computer.

5 38. The method of claim 37 including the further step of deserializing the stream of bytes to regenerate the mobile agent therefrom in the second computer.

10 39. The method of claim 36 wherein the task is data gathering, and including the further step of transmitting the mobile agent back to the first computer from the second computer following completion of such data gathering.

15 40. The method of claim 36 including the further step of causing the mobile agent to sequentially migrate to a plurality of destination computers within the computer network.

20 41. The method of claim 40 wherein the mobile agent further includes an itinerary which contains a reference to each destination computer to which the agent is designated to migrate and a reference to a method associated with each respective destination computer reference, and including the further step of invoking the method associated with the  
25 respective destination computer when the mobile agent is present on the respective destination computer.

30 42. The method of claim 41 including the further step of employing a Uniform Resource Locator as one of the at least one destination computer reference.

35 43. The method of claim 36 including the further step of searching for required executable code first in the computer on which the mobile agent is executing, then in the mobile codebase, and finally on the home codebase.

44. The method of claim 36 including the further step of forming a new thread in the destination computer for

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execution of the mobile agent following receipt thereof, and wherein a security feature prevents the mobile agent from operating outside a scope assigned to such thread.

5        45. The method of claim 36 including the further step of inserting sub-objects into the mobile agent.

10       46. The method of claim 41 including the further step of storing a persistent local copy of the mobile agent following receipt thereof, and overwriting such copy with an updated persistent copy following agent execution.



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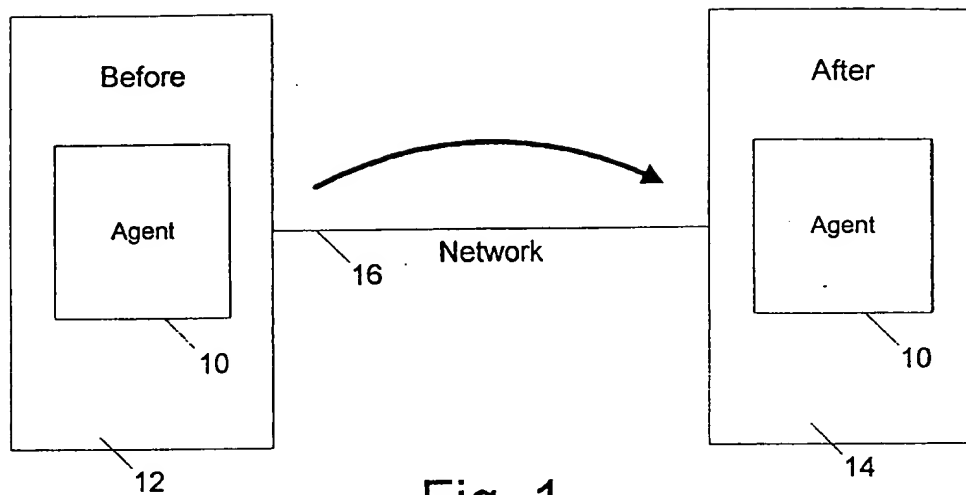


Fig. 1

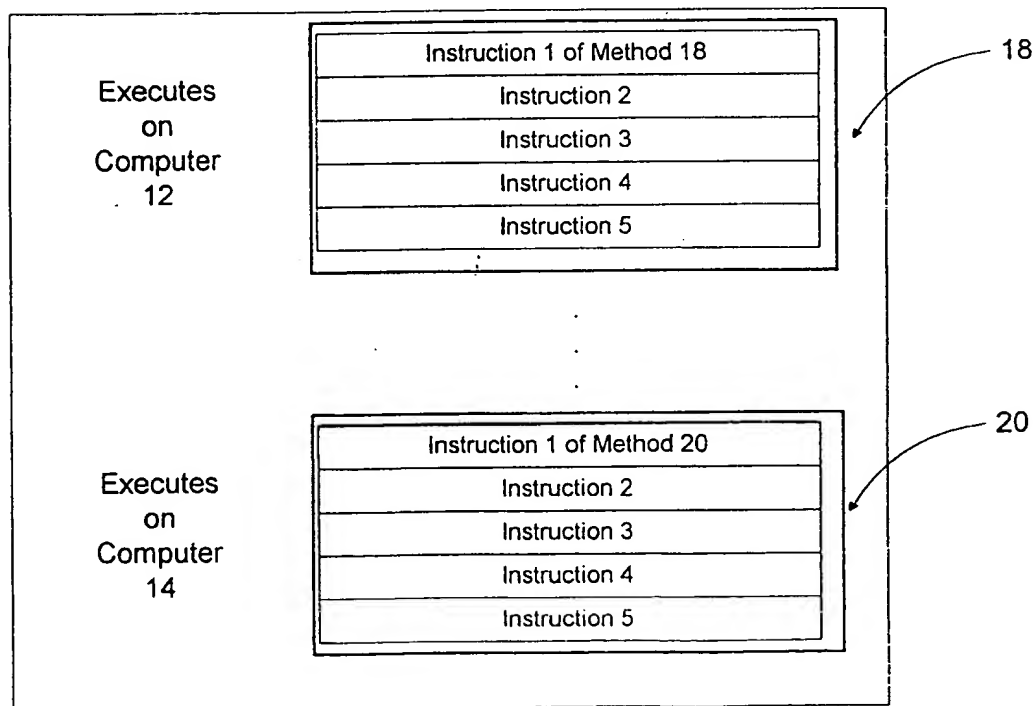


Fig. 2

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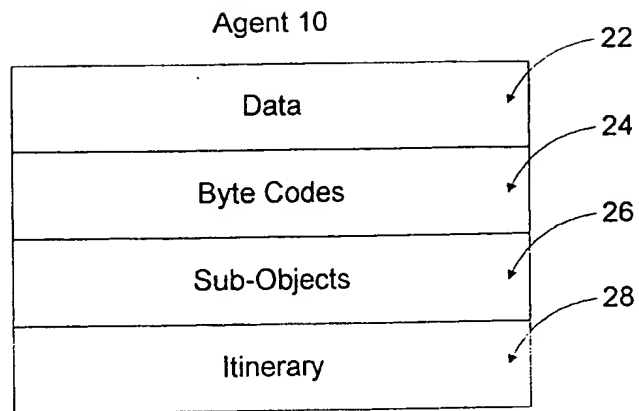


Fig. 3

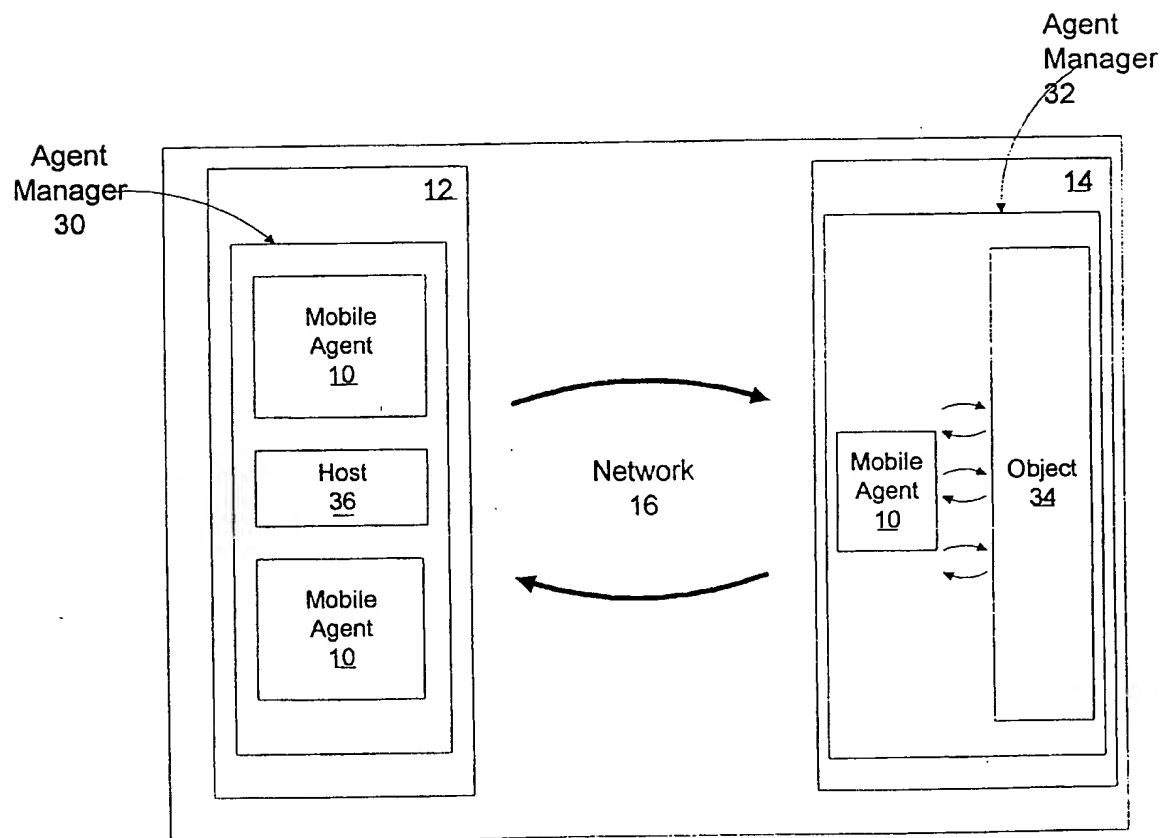
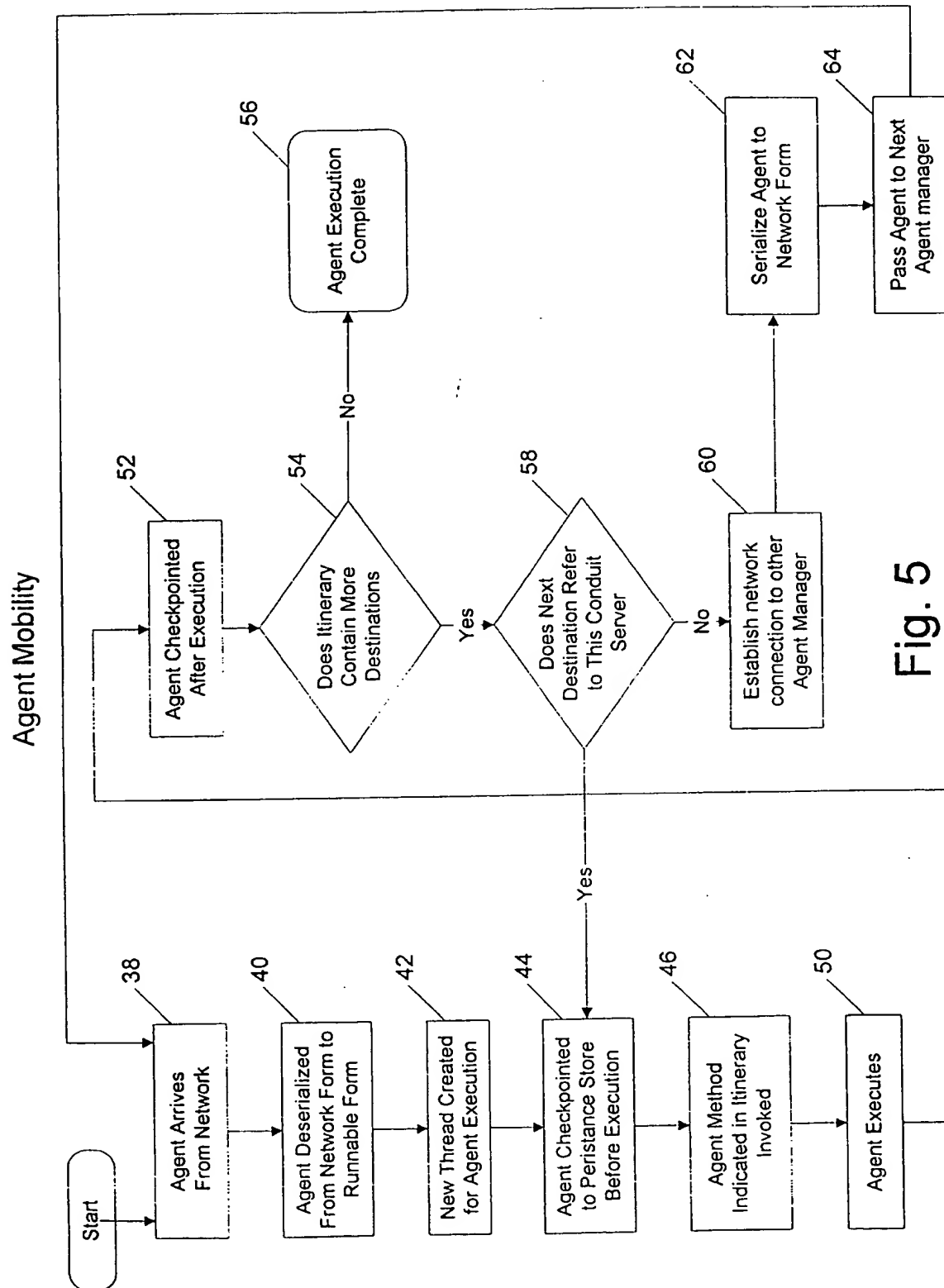


Fig. 4

**Fig. 5**

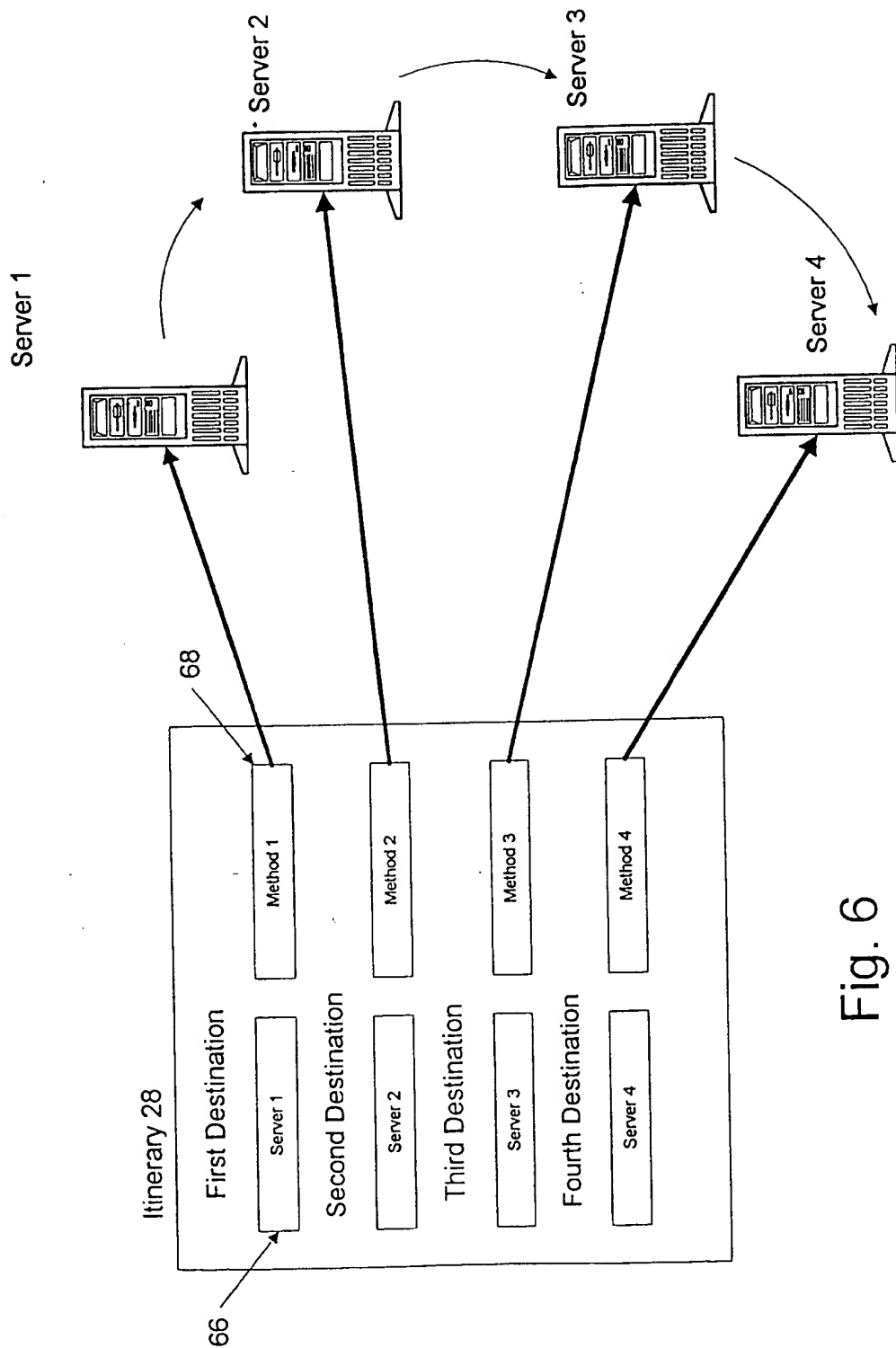


Fig. 6

Agent Runtime Environment

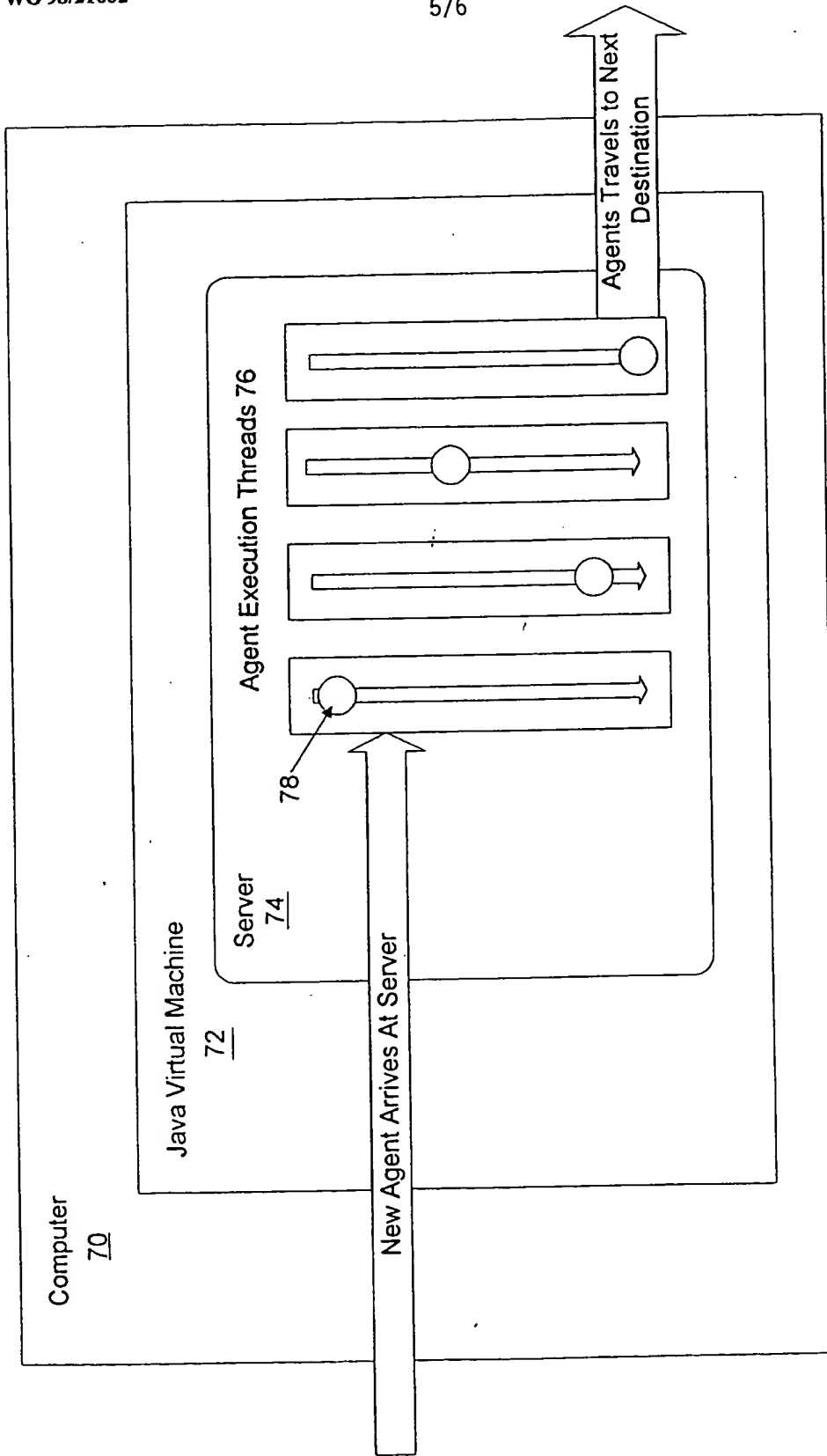
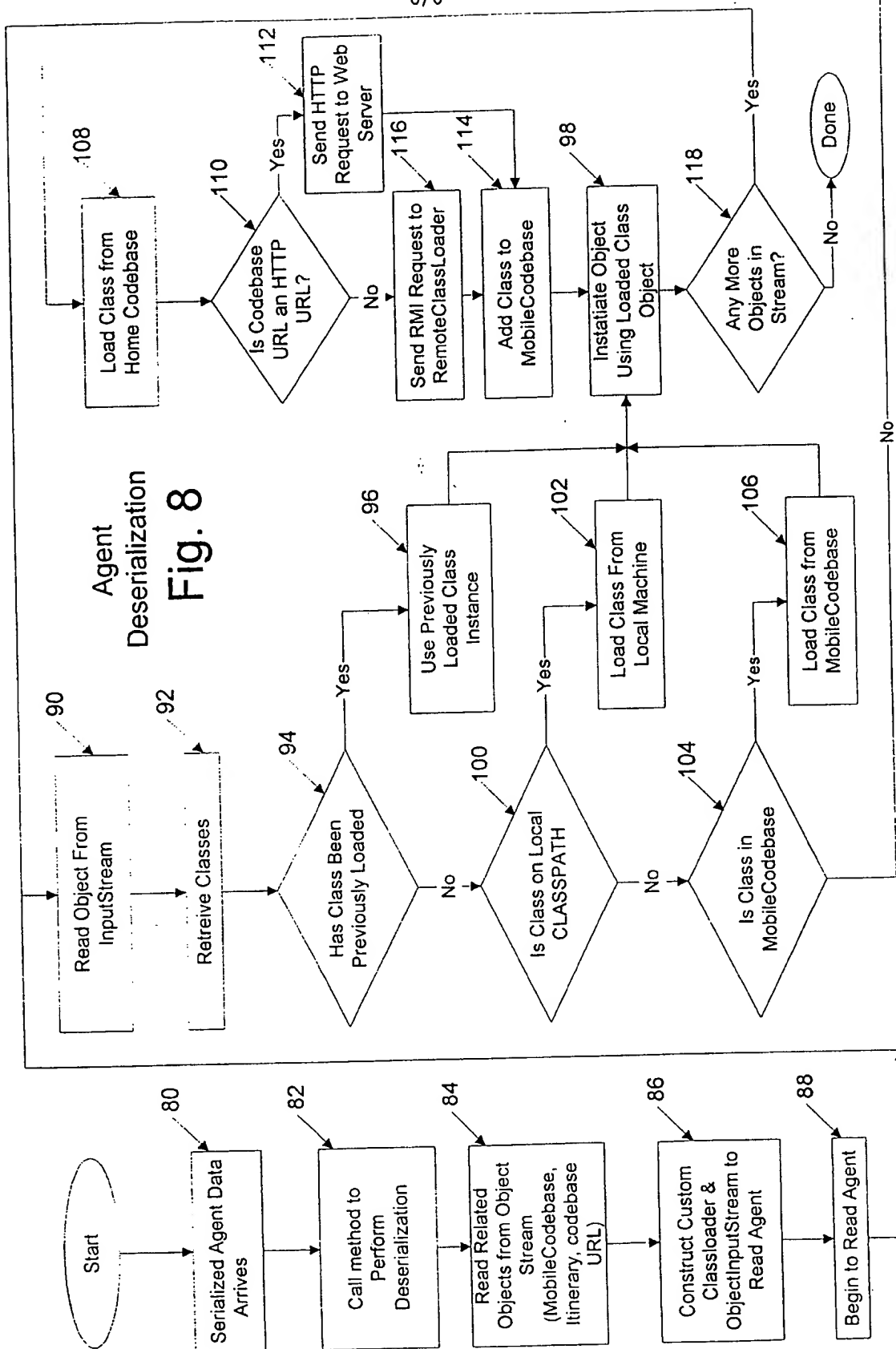


Fig. 7



## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US97/20232

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC(6) :G06F 13/00 US CL :395/200.32 According to International Patent Classification (IPC) or to both national classification and IPC																				
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) U.S. : 395/200.32 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) APS, IEEE																				
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>																				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																		
Y	BERGHOFF ET AL. Agent-based configuration management of distributed applications. IEEE. August 1996. Pages 52-59. Abstract and Introduction, pages 52-53; An infrastructure for mobile agents, pages 54-55; Agent-based configuration management, pages 55-57; and An agent-based management scenario, page 58.	1-46																		
Y	US 5,499,364 A (KLEIN ET AL) 12 March 1996, col. 1, lines 5-35; col. 3, lines 18-30; col. 4, lines 45-52; and col. 5, line 28 - col. 6, line 5.	1-46																		
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.																				
<table border="0"> <tr> <td>* Special categories of cited documents:</td> <td>*T</td> <td>later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>*A* document defining the general state of the art which is not considered to be of particular relevance</td> <td>*X*</td> <td>document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>*E* earlier document published on or after the international filing date</td> <td>*Y*</td> <td>document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>*G*</td> <td>document member of the same patent family</td> </tr> <tr> <td>*O* document referring to an oral disclosure, use, exhibition or other means</td> <td></td> <td></td> </tr> <tr> <td>*P* document published prior to the international filing date but later than the priority date claimed</td> <td></td> <td></td> </tr> </table>			* Special categories of cited documents:	*T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	*A* document defining the general state of the art which is not considered to be of particular relevance	*X*	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	*E* earlier document published on or after the international filing date	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G*	document member of the same patent family	*O* document referring to an oral disclosure, use, exhibition or other means			*P* document published prior to the international filing date but later than the priority date claimed		
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*E* earlier document published on or after the international filing date	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art																		
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*P* document published prior to the international filing date but later than the priority date claimed																				
Date of the actual completion of the international search 21 MARCH 1998		Date of mailing of the international search report 13 APR 1998																		
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230		Authorized officer LE HIEN LUU <i>Jon</i> Telephone No. (703) 305-9650																		

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